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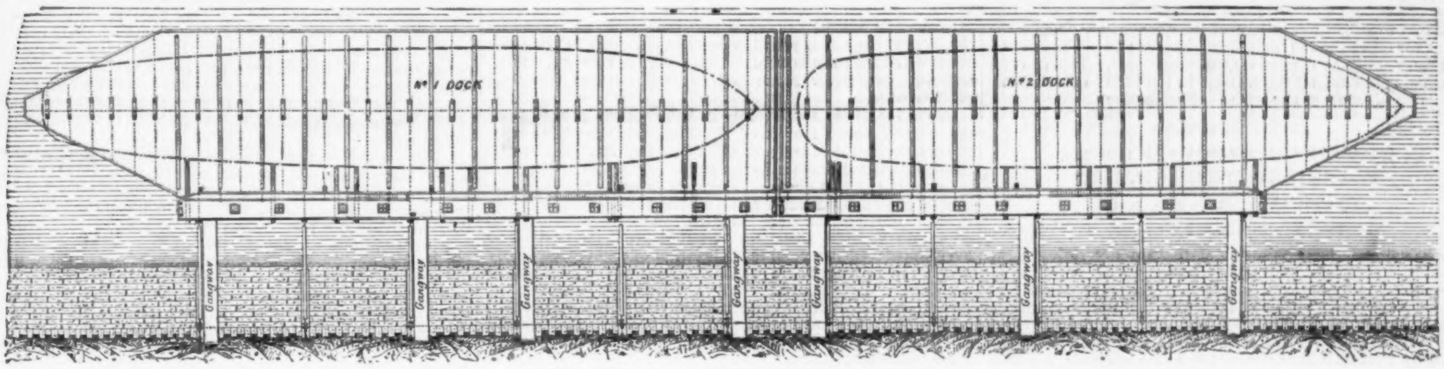
IMPROVED LIFTING DOCK.

WE illustrate a novel form of dry dock now being constructed by Messrs. Clark & Standfield at their new works at Grays, Essex, for the Dumfries Dry Dock Shipbuilding and Engineering Co., of Cardiff.

The dock is in two parts, as shown in the plan on this page, each of which can be worked independently, the larger part being capable of docking a vessel of 2,500 tons, and the smaller a vessel of 2,000 tons; the two united are



IMPROVED LIFTING DOCK.

capable of docking a vessel of 4,500 tons dead weight, and 500 feet or more in length.

In end elevation the dock has the general appearance of a very large landing stage, and could well be used as such when found convenient to do so. It resembles the letter L, the upright side of which is attached by eleven pairs of parallel motion booms to vertical girders built into the sea wall; the lower ends are embedded in concrete; and at the ground level these girders are secured by a horizontal anchorage. This connection insures that the dock shall be horizontal throughout the whole range of the tide, which is here about 42 ft.

Ample accommodation is provided for communicating with the shore by means of seven principal gangways, passing through passages in the side of the dock to the pontoon; these are hinged at their upper ends on the shore, and are furnished with rollers at their lower ends on the dock, so that they accommodate themselves to its rise and fall. There are also gangways on some of the upper booms, giving additional access to the upper deck.

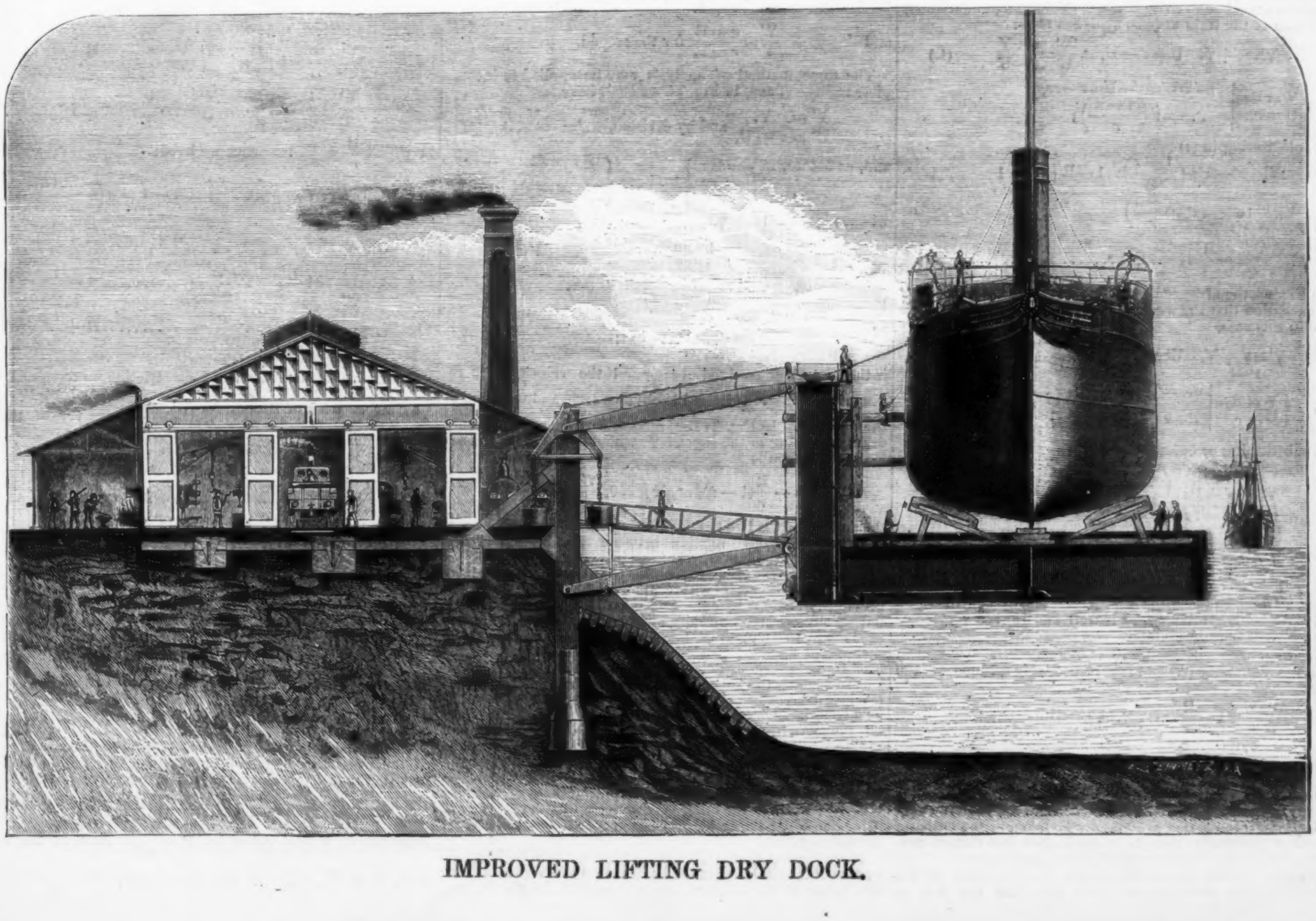
The dock having been lowered by allowing water to enter the bottom or pontoon, a vessel is brought over the keel blocks and rapidly centered by the mechanical centering shores shown as passing through the side of the dock; the pumps are then set to work till the vessel has a good bearing on the keel blocks, when additional blocks are brought up to thoroughly support the bilges, so that the vessel is firmly secured. Pumping is then resumed, and the water ejected from the pontoon until the vessel is raised completely out of the water, when the operation of lifting is completed.

The pumps are of sufficient capacity to enable the largest vessel to be docked within an hour, and not more than half an hour would be occupied by lowering her into the water. The advantage of this unusual rapidity will be very great, as it will enable a vessel to be docked, sighted, and again floated, and be taken to her loading berth in the wet docks within one tide.

The dock is divided both longitudinally and transversely into a large number of water-tight compartments, each of which may be pumped or shut off independently. The sluice valves are arranged and grouped in such a manner that they afford the most perfect control; they are provided with gear for automatically opening and shutting them, and also with manual gear which can be worked either independently of the automatic gear or in conjunction with it.

The automatic gear is arranged as follows: On the upper end of the vertical columns or girders an A-shaped frame is pivoted in gudgeons at its upper end, and at a certain distance below that point the shore end of the upper boom is connected to it by a steel pin, so that the A-frame can rotate freely on the gudgeons through a certain angle in either direction. From each leg of the A-frame is suspended a heavy weight. To the apex of the frame above the gudgeons is attached the rod connecting with the valve lifting gear on the dock.

Taking the dock in the position shown in the engraving, and supposing it be required to lower it, the whole of the interior valves are opened ready to admit water to the various compartments, the outer sluice valves are then raised, and the dock commences to lower. Should the outer side of the pontoon fill slightly faster than the shore side, and so have a tendency to list the dock in that direction, a pull is exerted upon the upper boom, causing the A-frame to be turned on its gudgeons, and the right hand weight to be lifted. A very slight traverse of the A-frame causes the rod above to actuate the valve gear, so that the valves admitting water on the outer side of the pontoon are closed, while those on the shore side of the pontoon remain open.



IMPROVED LIFTING DRY DOCK.

The dock is thus almost immediately brought back to a dead level, and the valves which have been previously closed are again automatically opened. A similar operation by the same gear controls the dock in the event of a tendency to list toward the shore.

There will be two centrifugal pumps in each part of the dock; they will be driven by powerful horizontal engines placed in the upper chambers of the vertical side of the dock. Whatever may be the level of the dock, steam is always in connection with the engines from the workshop boilers on shore, thus economizing weight and space in the dock.

The dock will be furnished with several vertical spring booms, as shown, along the side, and against these the vessel might be brought up without any shock when coming alongside. The side shores, shown as passing through the side of the dock, are worked by hand from the top deck by means of a worm and wheel gear. The extreme shores are used for bringing the vessel centrally over the keel blocks while she is still afloat, and the remainder are brought into position during the operation of lifting.

The bilge blocks consist of a very strong timber framework, and allow of a certain amount of spring, so as to give the vessel a secure seating, as shown. These are worked from the top deck by means of similar gear to that employed for the side shores, and they can readily adjust themselves to accommodate vessels of any shape.

Rails are laid along the whole length of the top deck, so that a steam crane can travel from end to end. Four gangway landers provide communication from the pontoon to the top deck, and also to the three painting stages which run from end to end. Every part of the dock will be able to be got at for cleaning and painting whenever required, as one part can readily be docked on the other part. Provision is also made for flushing the interior in the event of sediment being deposited from the water.—*Engineering.*

[Continued from SUPPLEMENT No. 441, page 7035.]

PLANETARY WHEEL-TRAINS.

By Prof. C. W. MacCord, Sc.D.

III.

It has already been pointed out that, in determining the action of a complete epicyclic train, the whole problem resolves itself into adding the motion of the train arm to that of each sun wheel, with due regard to the signs indicating the directions.

In relation to such trains, then, the general equation as given by Prof. Rankine covers the entire ground; but still there is a distinction between different arrangements of this kind which is not, we think, as sharply defined in that formula as its decided nature entitles it to be. The nature of this distinction may perhaps be better shown by examining separately one of each of the two classes into which these trains may be thus divided, in a manner different from that previously employed. Thus, in Fig. 22, let the two wheels, *a* and *f*, keyed upon the same shaft, turn in their bearings in the train arm, T, with an angular velocity, v; and supposing T to be for the moment stationary, let this rotation of the two planet wheels cause the sun wheels, A F, to rotate with the velocities U, V, respectively; and finally, let T revolve about the axis, C, with a velocity v', the arrows indicating the directions of these motions. Let rotations to the right, like that of the hands of the clock, be regarded as positive, those in the other direction as negative; then the result will be to give the sun wheels, A F, velocities differing from U and V; let them be represented by U', V'. Also, since in any given train the ratios of v to both U and V are known, we may write $V = Rv$, $U = rv$: and in order to make the action determinate, we may assign definite values to the veloicites of T and the wheel, A, and write $U' = nv'$. This being understood, the action of the train may be analyzed thus:

$$V' = v' + V, \quad U' = v' - U, \therefore \frac{V'}{U'} = \frac{v' + V}{v' - U} \qquad (1.)$$

$$\text{but} \left\{ \begin{array}{l} V = Rv. \\ U = rv. \end{array} \right| \begin{array}{l} nv' = U' = v' - U = v' - rv, \\ \therefore v = v'\left(\frac{1-n}{r}\right); \end{array}$$

and substituting in (1)

$$\frac{V'}{nv'} = \frac{v' - Rv'\left(\frac{1-n}{r}\right)}{v' - rv'\left(\frac{1-n}{r}\right)} = \frac{1 - R\left(\frac{1-n}{r}\right)}{n},$$

$$\text{or,} \quad \frac{V'}{v'} = 1 - \frac{R}{r}(1-n), \quad \ldots\ldots\ldots\ldots\ldots\ldots(A.)$$

In Fig. 23, the arrangement of the wheels is the same, with the exception that the wheel A gears internally with *a*. We have in this case,

$$V' = v' + V, \quad U' = v' - U, \therefore \frac{V'}{U'} = \frac{v' + V}{v' - U};$$

$$\text{also} \left\{ \begin{array}{l} V = Rv. \\ U = rv. \end{array} \right| \begin{array}{l} nv' = U' = v' - U = v' - rv, \\ \therefore v = v'\left(\frac{1-n}{r}\right); \end{array}$$

and substituting as before,

$$\frac{V'}{nv'} = \frac{v' + Rv'\left(\frac{1-n}{r}\right)}{v' - rv'\left(\frac{1-n}{r}\right)} = \frac{1 + R\left(\frac{1-n}{r}\right)}{n},$$

$$\text{or,} \quad \frac{V'}{v'} = 1 + \frac{R}{r}(1-n), \quad \ldots\ldots\ldots\ldots\ldots\ldots(B.)$$

Let us now suppose the first wheel, A, in each of these trains, to be fixed; which, as is well known, is a very common arrangement in practice.

We then have $U' = nv' = 0, \therefore n = 0,$
and the equations (A) and (B) respectively reduce to the forms

$$\frac{V'}{v'} = 1 - \frac{R}{r}, \quad \ldots\ldots(A').\text{— Differential.}$$

$$\frac{V'}{v'} = 1 + \frac{R}{r}. \quad \ldots\ldots(B'). \text{— Cumulative.}$$

Under these circumstances it will be seen at once that the two combinations are distinguished from each other by very striking characteristics, which may be taken as the basis for dividing planetary trains in general into two classes, properly designated "Differential" and "Cumulative."

In the former, as shown by Eq. A', the value of the velocity ratio between the train arm and the last or free sun wheel is the *difference* between unity and the fraction $\frac{R}{r}$; in the latter, it is the *sum* of these two quantities.

Now, it is evident that the value of this fraction may be very nearly equal to unity, and either greater or less, whatever the actual magnitudes of its terms. From which it follows that in the differential trains a very high velocity ratio may be obtained with comparatively small numbers of teeth; indeed, this ratio may be made infinitely large, since, if $R = r$, the last wheel will not turn at all, whatever the speed of the train arm.

It also follows that the train arm and the free sun wheel may be made to revolve in the same or in opposite directions; in the former case $\frac{R}{r}$ is less than unity, and the train may be called a *positive* one; in the latter, the fraction is greater than unity, and such a train may be called *negative*.

It will be further observed, that in a positive train the speed of the train arm must always be greater than that of the last wheel; but in a negative train it may be greater or less. In the latter, then, we may obtain the same velocity ratio in two different ways, and give the higher or the lower speed at pleasure to the train arm; since we may have either

$$\frac{V'}{v'} = 1 - \frac{R}{r} = -\frac{1}{s}, \text{ if } v' = -SV', \text{ or } s = \frac{r}{R - r},$$

$$\text{or,} \quad \frac{V'}{v'} = 1 - \frac{R}{r} = -s, \text{ if } v' = -\frac{V'}{s}, \text{ or } s = \frac{R - r}{r}.$$

In the cumulative trains, on the other hand, as shown by Eq. B', the free sun wheel must always turn in the same direction as the train arm, and with a greater velocity, which, however, can never reach infinity; these trains being all positive ones.

Of course, these results might have been deduced from the general formula of Prof. Rankine, given in the preceding article, and it is not pretended that any new facts are set forth in what immediately precedes. But the distinctive features of the two kinds of trains, it seems to us, are more clearly shown by deducing the expressions for the velocity ratio in the manner here adopted. And, indeed, it would seem that in some instances these distinctions have been overlooked; for we recall a description of one device nearly identical with Fig. 23, in which the operation was stated to consist of "a differential rotative action," and have often seen the term "differential gearing" applied to trains of substantially the same construction; which certainly cannot be considered as correctly indicating the manner in which these trains act.

And even if neither sun wheel be fixed, it will be perceived that there is an essential difference between the two classes. For Eqs. A and B may be written

$$rV' = rv' - Rv' + Rnv',$$
$$rV' = rv' + Rv' - Rnv';$$

and if we write $U' = nv' = mV'$, these will become

$$rV' = rv' - Rv' + RmV';$$
$$rV' = rv' + Rv' - RmV';$$

which give

$$\frac{V'}{v'} = \frac{r - R}{r - Rm}, \text{ for the differential train;}$$

$$\frac{V'}{v'} = \frac{r + R}{r + Rm}, \quad \text{" cumulative "}$$

These values for the velocity ratio, curiously enough, become reciprocal if the sun wheels rotate in opposite directions with equal velocities; in which case $m = -1$, and we have

$$\frac{V'}{v'} = \frac{r - R}{r + R} \text{ for the first train,}$$

and

$$\frac{V'}{v'} = \frac{r + R}{r - R} \text{ for the second.}$$

The same method of analysis may be applied to incomplete trains. Thus, in Fig. 24 we shall have

$$\begin{array}{l} V' = V, \\ U' = v' - U, \end{array} \text{ and by division, } \frac{V'}{U'} = \frac{V}{v' - U};$$

$$\text{and, as before, if } \left. \begin{array}{r} V = Rv \\ U = rv \\ \text{and } U' = nv' \end{array} \right\} \text{we have} \left\{ \begin{array}{l} U' = nv' = v' - rv, \\ \text{or} \quad v = v'\left(\frac{1-n}{r}\right); \end{array} \right.$$

whence by substitution,

$$\frac{V'}{nv'} = \frac{Rv'\left(\frac{1-n}{r}\right)}{v' - rv'\left(\frac{1-n}{r}\right)} = \frac{\frac{R}{r}\left(1-n\right)}{n}$$

$$\text{or} \quad \frac{V'}{v'} = \frac{R}{r}(1-n);$$

if the sun wheel be fixed, $n = 0$, and the velocity ratio reduces to $\frac{V'}{v'} = \frac{R}{r}$, as indeed is obvious from an inspection of the diagram. In Fig. 25 the process is the same, the only difference being in the sign of V, which is negative; the velocity ratio then is

$$\frac{V'}{v'} = -\frac{R}{r}(1-n), \text{ or, if } n = 0, \frac{V'}{v'} = -\frac{R}{r}$$

the actions of the two trains differing in no respect except as to the directional relation between the motions of the train arm and the last wheel.

It is in reference only to *complete* trains, then, that we have to consider the peculiarities upon which the classification previously made is based. And we shall find our attention not wholly occupied by such abstractions as the difference of signs in two equations, but that these peculiarities make themselves manifest in striking practical points. Not the least important of these is the feature of compactness, in respect to which the various trains above mentioned vary in a marked degree. In illustration of this, we give in Figs. 26–29 a train of each kind, the velocity ratio being the same in all, the teeth of all the wheels having the same pitch, and the first planet wheel of each train having 15 teeth; these drawings also are of course made upon the same scale.

The velocity ratio is that of 9 to 1; in the first two trains one revolution of T producing nine rotations of the last wheel F, while in the other two we have nine revolutions of T for one of F; the first train of each pair is positive and the second negative.

In comparing these trains, it is of interest to note the whole number of teeth in each, the lengths of the train arms, and the radius of the greatest circle described by the moving parts; which last is the sum of T and the radius of the larger of the two planet wheels. Then, letting

N = Total number of teeth,
T = Length of train arm,
L = Radius of greatest circle,

we have

Fig. 26.	Fig. 27.	Fig. 28.	Fig. 29.
A = 60	A = 75	A = 20	A = 25
a = 15	a = 15	a = 15	a = 15
f = 30	f = 60	f = 14	f = 16
F = 15	F = 30	F = 21	F = 24
N = 120	N = 180	N = 70	N = 80
T = 22·5	T = 45	T = 17·5	T = 20
L = 37 5	L = 75	L = 25	L = 28
$\frac{V'}{v'} = +9$	$\frac{V'}{v'} = -9$	$\frac{v'}{V'} = +9$	$\frac{v'}{V'} = -9$

We perceive, then, that in each pair the positive train is more compact than the negative; that the last two, in which the higher speed is given to the train arm, are very much more compact than the first two, in which the reverse is the case; and that of the first pair, the cumulative train has a very marked advantage in this particular over the differential train.

Of course, the above examples do not exhibit by any means the most compact trains that can be arranged, nor is it to be inferred that for every velocity ratio which can be produced in these four different ways, the compactness will vary in the same proportions as for the one here chosen. But so far as our observation extends, we have found that there is in all cases a considerable variation in this respect. The above comparison is one which we have never seen made, and since in some cases the actual space occupied is a matter of serious moment, the facts here illustrated may be of service, as indicating the most advantageous construction of trains for special purposes.

Again, it will be found that there is a great difference between these trains in respect to the amount of friction attending their action, which is much greater when the train arm has the high, and the free sun wheel the low speed, than when the contrary is the case.

In order to make a comparison, suppose that in each train power is applied to the quick moving shaft, in order to wind up a weight by means of a drum upon the slow moving one; and disregarding the friction of the journals, let us consider the work done against friction by the teeth only of the wheels, during one revolution of the drum.

The *friction* between two surfaces at any instant is the product of the pressure into a certain fractional coefficient; and the *work of friction* during a given time is equal to this friction, multiplied by the distance through which one surface slides over the other.

Now, during the action of two engaging wheels, the number of teeth in gear at any one instant may vary; also during the action of any pair of teeth there is a variation in the radii of contacts, and therefore in the pressure of one against the other. But the resultant kinematic action being equivalent to the rolling contact of the pitch surfaces, the average pressure may be considered the same as though there were all times but one point of contact, situated upon the pitch circumference.

The actual amount of sliding between any two engaging teeth will depend upon both their heights and the nature of the contours. But since the teeth are all supposed to be constructed upon the same system, and are of uniform pitch throughout, we may also assume that during one rotation of any wheel with respect to one with which it engages, the sliding will be directly proportional to its pitch circumference, or what is the same thing, to its pitch radius.

Let the angular velocities of the driving and the driven shaft be to each other as n to 1. Then the equations of these four trains will be, respectively:

$$\frac{V'}{v'} = \frac{n}{1} = 1 + \frac{R}{r}, \quad \frac{V'}{v'} = -\frac{n}{1} = 1 - \frac{R}{r},$$

$$\frac{V'}{v'} = \frac{1}{n} = 1 + \frac{R}{r}, \quad \frac{V'}{v'} = -\frac{1}{n} = 1 - \frac{R}{r};$$

in which $\frac{R}{r} = \frac{Af}{aF}$: whence we have:

$$\text{Fig. 26,} \quad n = 1 + \frac{Af}{aF}, \therefore \frac{Af}{aF} = n - 1 = n\left(1 - \frac{1}{n}\right) \ldots(1)$$

$$\text{Fig. 27,} \quad -n = 1 - \frac{Af}{aF}, \therefore \frac{Af}{aF} = n + 1 = n\left(1 + \frac{1}{n}\right) \ldots(2).$$

$$\text{Fig. 28,} \quad \frac{1}{n} = 1 - \frac{Af}{aF}, \therefore \frac{Af}{aF} = \ldots\ldots\ldots\ldots 1 - \frac{1}{n} \quad \ldots(3).$$

$$\text{Fig. 29,} \quad -\frac{1}{n} = 1 - \frac{Af}{aF}, \therefore \frac{Af}{aF} = \ldots\ldots\ldots\ldots 1 + \frac{1}{n} \quad \ldots(4).$$

Let m = coefficient of friction;
P = pressure, $\therefore m$P = inst. friction on teeth of f.
p = " $\therefore mp$ = " " " " " A.
w = work of friction for wheel f } per rev. of train arm.
w' = " " " " A' }
W = " " whole train }
W' = " " " " per rev. of drum.

Now during each revolution of T, the wheel f turns upon its axis $\frac{A}{a}$ times; and A turns once with respect to a, since a rolls once around A, the latter in fact being stationary. Therefore we have,

$$w = mP \times \frac{A}{a} \times f,$$
$$w' = mp \times A.$$

Between the values of P and p, there exists the relation,

$$p = P \times \frac{f}{a}; \therefore w' = mP \times \frac{Af}{a} = w:$$

and consequently in each case,

$$w + w' = 2mP \times \frac{Af}{a} = W; \ldots\ldots\ldots\ldots\ldots(5).$$

The actual value of P depends both upon the magnitude of the weight or resistance and upon the radius of the drum; supposing each to be unity, we have obviously in the last two trains, $P = \frac{1}{F}$; and in the first two, by the principle of virtual velocities, $P = \frac{1}{nF}$. Also, in the first pair, W = W', while in the second pair, $W = \frac{1}{n}W'$.

Substituting these values in Eq. 5, we find in the first two,

$$W' = 2\,\frac{m}{n} \times \frac{Af}{aF}; \ldots\ldots\ldots\ldots (6);$$

and in the last two,

$$\frac{1}{n}\,W' = 2\,m \times \frac{Af}{aF},$$

or,

$$W' = 2\,m\,n \times \frac{Af}{aF}; \ldots\ldots\ldots\ldots (7).$$

Finally, introducing into Eq. 6 the values of $\frac{Af}{aF}$ given in Eqs. 1 and 2, and into Eq. 7 the values of the same as given in Eqs. 3 and 4, we find that in

$$\text{Fig. 26,}\quad W' = 2\,m\left(1 - \frac{1}{n}\right) \ldots\ldots\ldots\ldots (8).$$

$$\text{“ 27,}\quad W' = 2\,m\left(1 + \frac{1}{n}\right) \ldots\ldots\ldots\ldots (9).$$

$$\text{“ 28,}\quad W' = 2\,m\,n\left(1 - \frac{1}{n}\right) \ldots\ldots\ldots\ldots (10).$$

$$\text{“ 29,}\quad W' = 2\,m\,n\left(1 + \frac{1}{n}\right) \ldots\ldots\ldots\ldots (11).$$

We see, then, that while the trains in which the drum is carried by the free sun wheel are much the most compact, their action is attended with very much more friction than that of the others, in which the train arm carries the drum. And in comparing the two positive trains, as Fig. 26 with Fig. 28, or the two negative ones, as Fig. 27 with Fig. 29, we observe that the work of friction is directly proportional to the velocity of the train arm, the velocity of the drum being the same in each case.

It will now be of interest to compare these trains with the ordinary arrangement having fixed axes. In order that the conditions may be as nearly as possible similar, we have selected, as shown in Fig. 30, a train composed of two wheels, *a*, *F*, and two pinions, *A*, *f*; the latter having each 15, the former each 45 teeth, thus giving the same velocity ratio of 1 to 9 as in the preceding cases; the drum also is of the same size.

Proceeding as in the investigation of the planetary trains, we find the value,

$$W = 2\,m\,P \times \frac{Af}{a},$$

for the work of friction of the whole train per revolution of *A*, which makes n turns for one of the drum. We have also,

$$P = \frac{1}{F},\quad W = \frac{1}{n}W',\quad \frac{Af}{aF} = \frac{1}{n};$$

and substituting,

$$\frac{1}{n}W = \frac{2\,m}{F} \times \frac{Af}{a} = \frac{2\,m}{n},$$

whence finally, in Fig. 30, $W' = 2\,m$ ....(12).

Taking the work of friction in this combination as unity, then, the comparative values of these five arrangements will be as follows:

Fig. 30,	$W' = 1$	1	For vel. ratio 1 to 9.
“ 29,	$W' = n\left(1 + \frac{1}{n}\right) = n + 1$ ..	10	
“ 28,	$W' = n\left(1 - \frac{1}{n}\right) = n - 1$ ..	8	
“ 27,	$W' = 1 + \frac{1}{n}$	$\frac{10}{9}$	
“ 26,	$W' = 1 - \frac{1}{n}$	$\frac{8}{9}$	

It must be kept in view that these expressions are merely comparative, and do not in their present forms express the actual amount of the work of friction.

We deem the proposition above advanced, that the work of friction during the rotation of a wheel will be proportional to its circumference (the pitch of the teeth being uniform throughout the train), because the sliding between the two engaging teeth during their action is a definite fraction of the pitch arc.

It will, however, not be equal to the circumference, but a certain fraction thereof, giving a *coefficient of sliding*, just as the coefficient of friction is a certain fraction of the pressure. Then let

r = coefficient of sliding,
G = weight to be raised,
D = diameter of drum,

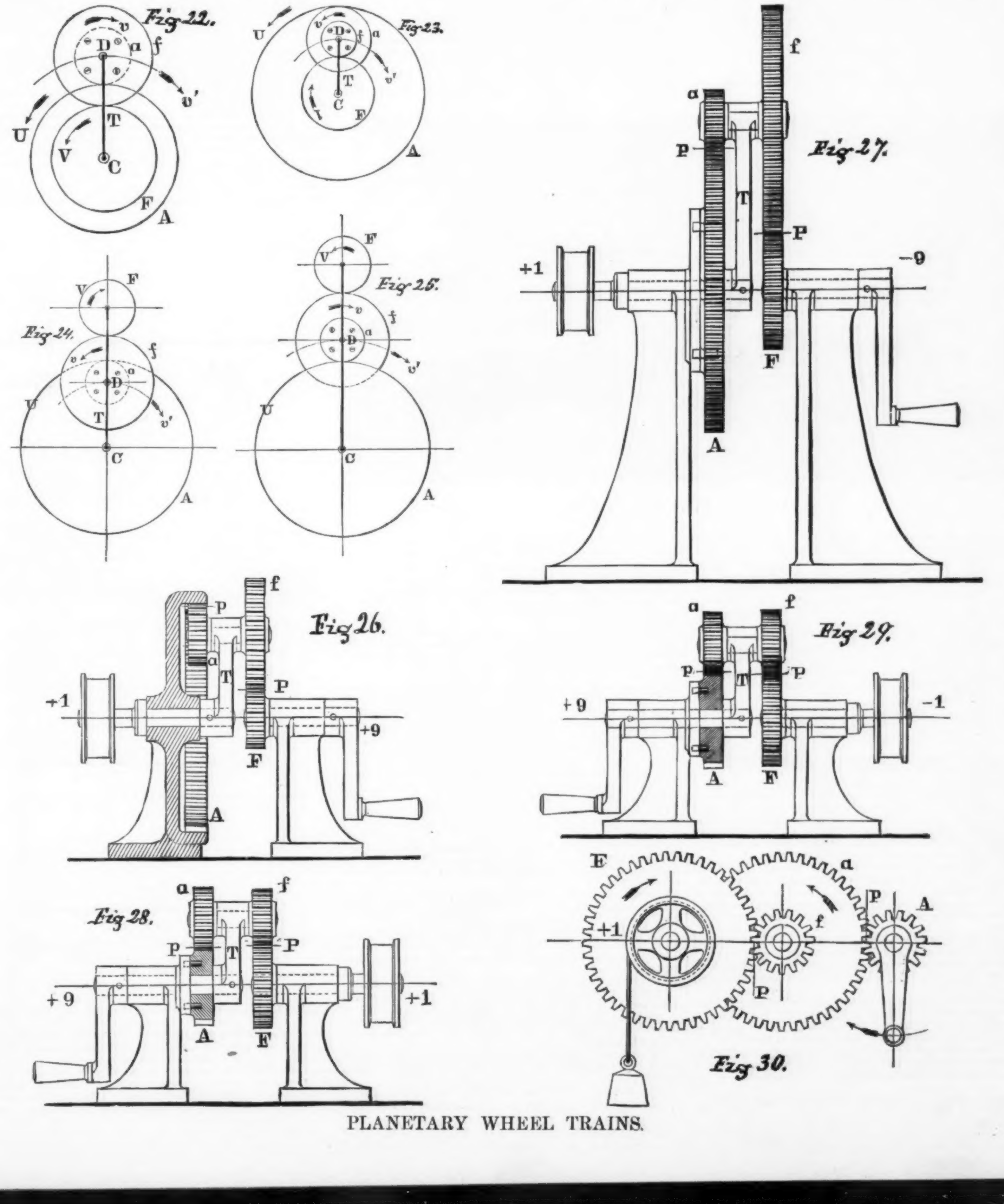
and we shall have in Eq. 12,

$$W' = 2\,m\,(r\,G\,D \times 3{\cdot}1416),$$

as the actual amount of the work of friction per revolution of drum; and Eqs. 8–11 must be correspondingly modified by the introduction of this parenthetical factor into the second number of each.

The coefficient of friction, as is well known, depends upon the material, finish, and lubrication of the surfaces, and must be determined by experiment. The coefficient of sliding, however, depends upon the forms and proportions of the teeth, and is determined by measurement from the drawings. Thus, during the arc of approach, the acting flank of the driver is less than the face of the follower, by a certain amount; during the arc of recess, the acting flank of the follower is less than the face of the driver, by another certain amount; and the sum of these differences is the total sliding during the engagement of one tooth with another.

Let s = this sliding for one tooth,
“ S = total sliding for revolution of wheel,
“ t = length of pitch arc.



PLANETARY WHEEL TRAINS.

then $S = s \times$ (No. of teeth).

But No. of teeth $= \frac{\text{circum}}{t}$

$\therefore S = \text{circum.} \times \frac{s}{t}$,

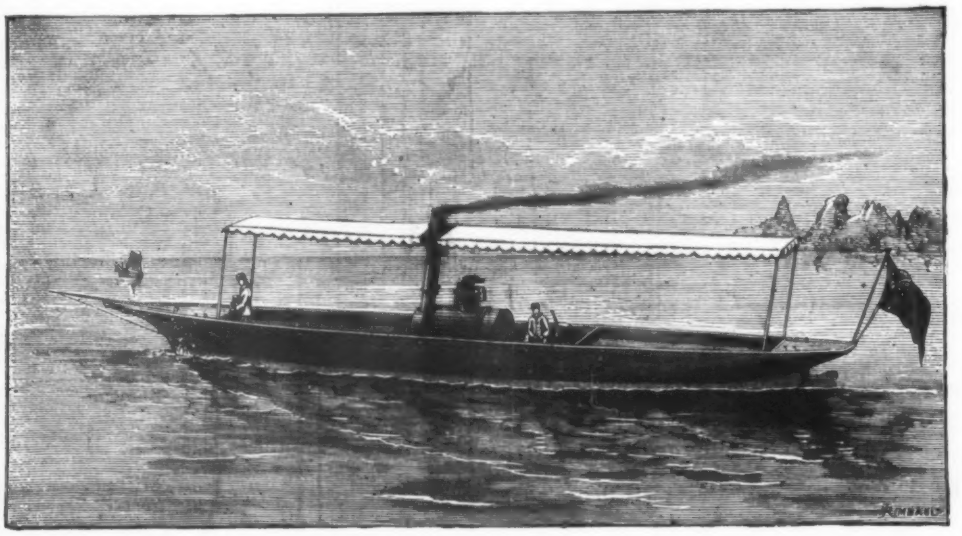
and $\frac{s}{t}$ is the coefficient of sliding, denoted by r in the preceding investigation.

It may be urged that if more than one pair of teeth are simultaneously engaged (as, indeed, is usually the case), the amount of sliding will be greater than this. Which is true; but the pressure being subdivided, the friction of each tooth will then be less. It may not be absolutely exact in all cases to assume, as we have done, that these two things will balance each other; but it is our conviction that the error will be so small as to be practically unimportant; and at any rate the comparison between the various trains, which it was our main object to make, is not affected by it.

It must not be inferred that the trains shown in Figs. 28 and 29 are of limited utility by reason of the great amount of friction that attends their action. Their compactness, consequent lightness, and simplicity render them peculiarly eligible for some purposes, more particularly in hoisting machines; and in this special application the very existence of this friction is rather an advantage than a drawback, since the weight cannot run down if the power be relaxed or the engine fails; contingencies which with other arrangements of mechanism have caused serious accidents.

A DELTA METAL YACHT.

IT is well known that vessels built of thin steel will rust through rapidly if not kept constantly painted. This is found to be the case to a remarkable extent in such vessels when navigating the rivers draining the interior of the African continent, the waters of which possess the power of corroding and eating through steel plates very rapidly. A steam launch called the Delta has therefore been built entirely of this metal by Messrs. Yarrow & Co., of Poplar. The length of the launch over all is 36 feet, with a breadth of beam of 5 feet 6 inches, and a depth of gunwale to keel of three feet, the vessel being capable of seating conveniently twenty-five persons. Delta metal, which is an alloy of copper, zinc, and iron, having been proved by repeated experiments to be equal in strength, ductility, and toughness to mild steel, the



A DELTA METAL YACHT.

plates and angle pieces are of the same thickness they would be if steel were used, viz., $\frac{3}{32}$ of an inch. The stem, keel, and stern post are of forged Delta metal, and scarfed together, as is usually done. The angle frames are of the same material, and are placed longitudinally instead of transversely, by which arrangement greater longitudinal strength is obtained. The screw propeller is cast in Delta metal, and is four-bladed, 2 feet 4 inches in diameter, and with 3 feet pitch. The engine is of the usual direct-acting inverted type, and of sufficient power to give a speed of from eight to nine miles an hour. The application of the Delta Metal to the present purpose is of interest just now, when attention is being directed to the development of the African continent.

THE CONSTRUCTION OF FRAME BUILDINGS.*

By CLARENCE O. AREY, C.E.

I HAD intended when I selected the above title for my paper to take up the different classes of frame buildings, but after starting upon my subject I saw that, if I confined myself to the construction of the balloon framed dwelling, I should cover ground enough for one paper. I shall therefore take up the different points in which, according to my ideas, such buildings as constructed in this locality are faulty, and bring forward the qualifications necessary in order to have such a building properly constructed.

The two main requirements to secure this are: First, that there shall be as little settlement in the building as possible, and that whatever settlement there is shall be the same in amount in all parts of the building; second, that the frame shall be perfectly stiff against both dead weight and wind pressure.

In starting, it must, of course, be taken as one of the conditions that our foundation is solid, that the pieces that carry weight in the cellar bring as much weight upon their footings per square foot as the outside walls have upon their base per square foot.

Also we must consider that the tops of piers carrying the same line of girdles are level, so that they do not require to be completed by putting different thicknesses of plank on them in order to correct their inaccuracies of level.

The old-fashioned braced frame, if properly constructed, fills both the conditions of settlement and stiffness, were it not that there is so much settlement in all parts.

Although the majority of the architects in the East have gone back to the braced frame after a trial of the balloon, I do not think that they can accomplish the same results with the degree of economy that the balloon frame gives. The balloon frame is still capable of many improvements, its weakest point being in the ribbon which carries the joists of the upper floors. It has also the disadvantage of having a greater amount of vertical timber than is necessary to carry the weight it receives, in order that the studs may be the proper distance apart for lathing. In order to compensate this, we use studs of a size that hardly gives a wall of sufficient thickness for proper window boxes.

I have been developing a modification of the balloon frame which I propose to bring into use in my own work, and which, I think, will overcome these difficulties; but my purpose this evening is to discuss the balloon frame as it is, so that this will not properly form part of my subject.

In discussing the framing the sheathing will be left out of consideration entirely, as being a factor that adds to the strength of the building; for if we depend on the sheathing to carry weight, we at once get the question of settlement from the shrinkage of horizontal timber so complicated that it would be impossible to tell the amount of shrinkage timber that we have at any one point of the building, while if the frame is so constructed as to fulfill the condition of settlement the sheathing will then come in place to give the building warmth and general, not entire, stiffness against the wind.

The necessity of equality of settlement is indicated by Fig. 1.

The figure represents a door opening in a cross partition that rests upon joists. If the joists settle more at one end than at the other, the floor settles as indicated by the dotted lines, and the door opening loses its rectangular form, while the door, being hung at right angles with the door jamb, will not shut. This point is quite clearly explained in Clark's Building Superintendence.

To properly discuss the conditions of stiffness and equality of settlement, it will be better to take the building in its different parts and consider what is necessary in order that each part may fill the requirements.

Sills, Girders, and Plates.—I consider the sill built of plates, and so common in this locality, to be thoroughly bad. In the first place, in a sill or beam built of more than one horizontal thickness there is a loss of strength in exact proportion to the number of thicknesses employed. That is, if a beam of two horizontal thicknesses, you have exactly one-half the strength of the same amount of timber in one thickness. In a sill of three thicknesses you have only one-third the strength of a timber of the same dimensions in one thickness. To prove this we have simply to fill Rankin's formula for beams.

$B.\ M. = n f b h^2$.

$B.\ M.$ is an abbreviation for bending moment.

n being a constant depending on the section of the beam.

f being a constant depending on the material used.

b and h being the breadth and height.

A beam of any number of horizontal thicknesses, unless properly keyed and bolted together, must be considered as so many separate beams of the thickness of each, so that in getting the comparative strength of a beam of one thickness, and a beam of several thicknesses with the same total dimensions, we must fill the formula for the first case with h representing the total depth of the beam, and for the other with h representing one thickness of the beam, and multiply the result by the number of thicknesses.

All the factors excepting h remain constant.

For a beam of two thicknesses h being the depth of the beam of one thickness, h would become $\frac{1}{2} h$ and squared $\frac{1}{4} h^2$; doubling for each part of the beam it becomes $\frac{1}{2} h^2$. In the same manner for three thicknesses the h^2 for one thickness becomes $\frac{1}{3} h^2$. Substituting n for the number of divisions, we obtain for n thicknesses $\frac{1}{n}$th of the strength for one thickness.

I have perhaps been unnecessarily explicit on this point, but my excuse is that it is a fact so commonly misunderstood outside of the engineering profession.

During the summer of 1881 I noticed in a large dwelling going up on the Chamberlin Allotment in this city, that the sills were made of two pieces of 2 inches $\times$ 6 inches, spiked together.

Examining them over one of the cellar window openings, I found a deflection of fully $\frac{1}{4}$ inch in a span of about 3 feet 0 inches. By this we see how such a sill will settle over an opening; and also if the foundation settles for a short distance in any part of the building, how this class of sill will settle with it.

For different reasons from the ones I have against built sills, I object to girders built out of joists on edge and spiked together.

First, you cannot make a good splice and have it entirely upon a bearing. Bolsters are not allowable in this class of building, on account of bringing in too much shrinkage timber.

In this connection I will mention a case where I made some alterations in an almost new dwelling on Willson Avenue. I found that the girders in the cellar were made of three pieces of 2 inches $\times$ 10 inches on edge. In a span of some 8 or 9 feet the middle joist was spliced about 3 feet from one of the piers; the splice being simply one joist ending and another commencing, leaving really only a double joist to form the girder.

Second, as we cannot get absolutely dry timber in the market, several thicknesses of timber nailed together without

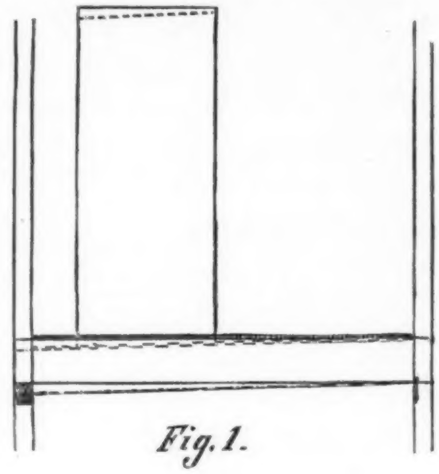


Fig. 1.

any air spaces between them have a decided tendency to dry rot. If these girders were keyed apart, leaving an air space between each division, after the manner of the chords of a Howe truss, they would be in all respects equal, if not superior, to a solid timber.

Having considered sills and girders with regard to strength, there still remains the consideration of equal shrinkage throughout the building. It will be assumed that all of the timber is of sufficient strength to avoid appreciable deflection. I suppose that it is understood that timber shrinks across its grain, but not lengthwise of its grain to any appreciable extent. By the term shrinkage timber, which I shall frequently use, I mean the timber which lies horizon-

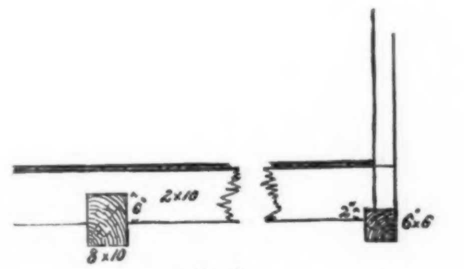


FIG. 2.

tally in a building, and which carries joists, floors, or partitions upon it. Let us take a building in which the inside partitions, which carry joists, are carried by girders upon piers, and all studs that carry joists go through between the joists at their foot and rest upon the sill, girder, or plate below.

If the sills and girders are of unequal depth, the first floor may be made to have equal settlement by sizing the joists of this floor unequal amounts at the two ends—that is, if we have a 6 $\times$ 6 inch sill and 8 $\times$ 10 inch girder on edge, on account of having 4 inches more timber vertically, we require, in order that the floor may settle equally, 4 inches less of the joists resting on the girder than on the sill, as in

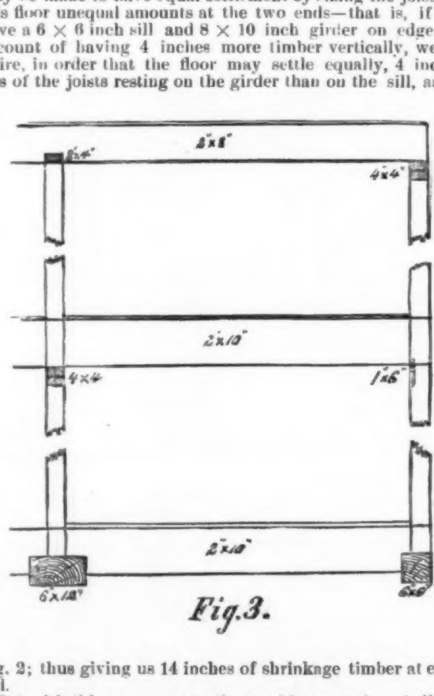


Fig. 3.

Fig. 2; thus giving us 14 inches of shrinkage timber at each end.

But with this arrangement the trouble comes in a balloon frame when we reach the third or attic floor. For the second floor we need at least a 4-inch plate on the top of the first floor studs that rest upon the girder; this, with the case already taken, will give us 14 inches of shrinkage timber without the second floor joist timber. If we set this plate into the joists 4 inches, the joists being 2 $\times$ 10 inches, we

* A paper recently read before the Civil Engineers' Club of Cleveland.

shall have 20 inches of shrinkage timber at this inner end of the joists. At the outer end we have 6 inches from the sill; the ribbon will probably set into the joists so as to leave 9 inches shrinkage timber in them. This makes 15 inches. To make up the 20 inches we need a 5-inch ribbon. The shrinkage of the ribbon not being exactly certain on account of its nailing, it would be better to use a 6-inch one.

Under the inside ends of the third floor or attic joists, if there are 4-inch plates at the top of the second floor studding, we have, adding this to the 14 inches below, 18 inches of shrinkage timber.

Under the outside ends we have, adding the 4 inches of the plate to the 6 inches of sill, 10 inches of shrinkage timber.

This would require us to cut 8 inches further into the inner ends of the attic joists than the outer, which is impracticable. Now let us start with the sills and girders of the same depth, and see how it simplifies the matter. (This case illustrated by Fig. 3.) I do this in practice by using 6 × 6 inch sill and a 6 × 10 inch or a 6 × 12 inch girder laid flat; the distance between the piers being proportioned to the weight.

If the first-floor joists are sized out so as to leave the same amount at each end, they will settle evenly as the timber dries. If a 4-inch plate is used on the top of the interior carrying partitions under the second floor, and a 6-inch ribbon (considered as equivalent to 5 inch) is used in the outside studding under the same floor, and is set into the joists 1 inch, we have 20 inches of shrinkage timber at each end of the joists for the sizes given in Fig. 3. I object to a 2-inch plate on the top of the studding that carries the second floor joists as being too light for a span of 16 inches to carry both the second-floor joists and the second-floor studding resting directly upon it. If this plate only carried one set of joists and not the partition above it, it would be sufficient. If under the attic joists a 4-inch plate is used on the outside wall and a 2-inch plate at the top of the inside partition, and this latter is set into the joists above it 2 inches, we have 18 inches of shrinkage timber from the foundation to the top of the attic joists at each end of them. In practice if the attic have no finish whatever, I generally use a 4-inch plate on the top of the interior bearing partitions, just under the attic joists. If it is desirable to raise the roof so as to have some height in the attic at the eaves, by setting a 6-inch ribbon into the studding and letting it into the attic joists 1 inch, the same as is done under the second floor, we still keep both ends of our joists resting on an equivalent amount of shrinkage timber.

There came under my attention during the past summer a frame dwelling in which there were 6 inches more horizontal timber at the inner ends of the first-floor joists than at the outer ends, 10 inches more in the second-floor, and 26 inches more in the attic floor. I have heard the owner since complain that the plaster cracked in all the angles, of course; as by settlement the shape of the cross walls changes from rectangles to acute and obtuse angled parallelograms, the junction between these cross walls and the supporting walls must be severed, as plaster has no element of elasticity.

In this connection it may be well to mention that cracking of plastering is more generally the fault of the carpenter than the plasterer. Splintering, which is hardly the correct name for it, is generally caused by unslaked lime, or by work done in winter under artificial heat, under which conditions good work can never be obtained.

Framing Over Openings.—For openings not over 3 feet 0 inches in width I find that doubled 2-inch plates set into the studding on each side of the opening have sufficient strength. This setting in, although neglected by the carpenters unless carefully watched, is absolutely essential; otherwise we put in a timber amply strong, and hold this timber by a few nails which have nothing like the necessary strength.

Over openings wider than this I think it is best to truss. Although a joist set into the studding on edge is strong enough, unless it is absolutely dry it complicates our problem of shrinkage. In trussing it is necessary to see that the truss is a truss, and not a semblance of one held in place by a few nails.

It is wonderful what an amount of ignorance is displayed in the construction of simple trusses. Heavy timber is put in with no duty to perform whatever. Struts are used where there should be ties. Timbers of size only sufficient to withstand a direct thrust or pull are put under heavy bending moment. We hardly see all of these conditions in the little trusses of which I am speaking, but there are plenty of them built that might as well be left out as far as any purpose being accomplished by them is concerned. Perhaps the simplest form of a good truss for such places is that

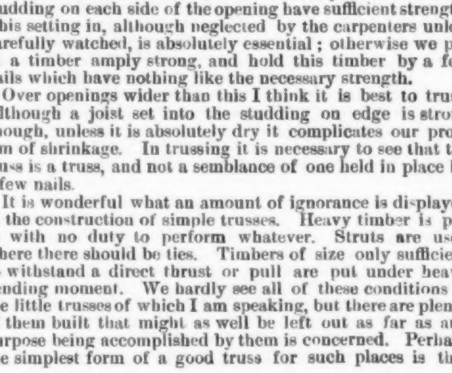


Fig. 4.

shown in Fig. 4. The pieces a a a a are set in after the truss is built for the purpose of lathing.

If the truss is very flat in proportion to its height, the doubled studding on each side of the opening will not be sufficient to withstand the horizontal thrust, and the struts will either need to be set into the tie B, or the two or three studs on each side of those forming the opening will want to be blocked together at the level of the tie B.

Stiffening the Walls of the Building against Wind Pressure.—This is a precaution to which generally very little attention is paid in balloon frames. This end may be accomplished in several ways, as follows: By setting into the studding diagonal 1-inch dressed boards at the angles of the building, and nailing to every stud which the diagonal crosses; by running a row of zigzag bridging all around the building between the studding; by bricking up a short distance between the studding. This fixes the lower ends of the studs solid, and makes them all act as beams fixed at one end.—By covering the walls with narrow matched sheathing. Covering the wall with common sheathing is not an entire precaution against displacement by wind pressure, because by a very slight giving way of the wood against the side of the nails each board may have a parallel motion in the same manner that a parallel ruler acts. The matched sheathing, to be efficient, must be nailed on both edges, and not simply blind-nailed like flooring. In this case the matching and the fact that the narrowness of the boards makes less leverage between each pair of nails produce the superiority for this purpose over common sheathing. I do not consider that even the matched sheathing is as good a means of resisting wind pressure as the first few mentioned.

The Order of Progress.—It is customary with some contractors to space the studding equally distant all around the building, then to sheathe, and after this to cut out the openings wherever they may come. I have never seen a case of this in which the framing around openings was not a mere pretense, the framing studding being merely tacked into place against the sheathing, the studding that was originally set up carrying the weight against all openings to the studding. Sometimes the openings are not even framed till the roof is raised, then if the opening is wide and the roof is heavy, the wall-plate, being unsupported during the cutting out, settles out of level, where it permanently remains. It is my custom now to specify that the building shall not be sheathed till all openings have been framed, and that the roof shall not be raised till the building has been sheathed.

Before any lathing is commenced it is necessary to see that all angles have been made solid, and in making an angle solid it is necessary that the end studs of the partitions that form the angle shall be against each other. This is so that each room may be lathed by itself and have no lath running through from one room to another. When the laths run through in this manner the two angle partitions have no connection with each other, and any jar in one of them will not affect the other, so they spring apart and crack the plastering down the angle. Where a frame partition joins a chimney there is only one way of preventing a crack, and that is by furring all around the chimney with wood, and this I should not recommend unless the chimneys have 8-inch outside walls.

Sheathing and Siding.—Sheathing a building on the outside is altogether preferable to sheathing it on the inside. When a building is sheathed on the inside the spaces between the floor joists are generally left open, letting the cold air pass in, and making cold floors; also the clapboards on the outside, being only ½ inch thick in their thickest place, have a tendency to spring in different curves between the studding, thus opening a space for the inlet of cold air. Sheathing on the inside has the disadvantage of having no grip on the angles of the building; and any building paper used in this case loses half of its efficiency by having nothing to hold it flat in place and keep its lapped joints tight together.

On the other hand, if the building is sheathed on the outside the sheathing runs up continuously, gripping the angles and covering the ends of all joists. It keeps the clapboards close against each other, and packs the building paper tight between the clapboards and sheathing. In comparing these two methods of work, I have spoken of the building as if clapboards were the only covering. I consider it the only good covering to the outside of a frame building excepting shingles. Drop-siding either leaves large spaces to hold water, if the casings are laid on top of it, or it splinters on the end from the lack of an air space behind it if it is butted against the casing. Clapboards from being thinner at one end than at another, and from their lapping each other, leave a triangular air space between every two consecutive ones and the sheathing, which greatly enhances their durability.

In general, air spaces between consecutive pieces of timber in a frame building are essential to its durability.

Roofs.—These have both dead weight and wind pressure to resist. I shall leave out of consideration roofs covering large spans, requiring frame trusses, and take up only the ordinary roof and such trussing as may be put together with spikes acting as rivets or pins. My idea of the ordinary roof is that the hips, valleys, ridges, and wall rafters should form a frame, not necessarily strong enough to carry the whole roof, but strong enough to act as a decided stiffener to the whole. The common rafters in this case act almost entirely as filling. The valley rafters are almost always made too light, the fact not being taken into consideration that they have to carry the weight that is on all the rafters that butt against them.

Where the rafters are 2×6 inches, a doubled 2×8 inches is necessary for the valley rafters. Hips and ridges should never be less than 2 inches thick, and deep enough to receive the diagonal dimensions of the rafters. If these are less than 2 inches thick, we do not have straight but wavy ridge and hip lines. In one of the first buildings that I erected in this city, which was built by the day, I had specified the ridges 2 inches thick. As the building went on the owner wished to economize as much as possible, and a 1-inch ridge was put in. This building happened to have an exceptionally long ridge and a good place to illustrate the weak point of a 1-inch ridge-pole.

When the attic floor was laid, I took the owner into the attic at one end of the ridge and had him sight along it. The straightness of the ridge averaged all right. It was as much out on one side as it was on the other; it was like Mark Twain's watch, which was all right at 12 o'clock at noon every day, but the rest of the time he could not tell whether it was slow or fast. The workmen employed on this building were experienced and careful men.

The attic of a dwelling may just as well and cheaply be made clear and unobstructed between its outside walls as to be all cluttered up with posts supporting angles of the roof. If the roof is properly framed it does not need this, even if it has a deck. If in each case where two valley rafters come together one of them is run through to the ridge or deck plate, if no spliced timber is used, and if the roof is properly braced against the wind, the most complicated roof can be made to stand without intermediate supports. Of course each case will want special study. When supports are put in the roof is framed to rest on them, so that they cannot be removed, and if ever it becomes desirable to divide the attic into rooms they are always just in the wrong place. If the attic is ever furnished off as a dancing hall, the posts are terribly in the way.

It is much easier to dodge two couples than it is to dodge two couples and a post at the same time. In the more complicated roofs without decks, the timbers run from so many different directions that they brace themselves against the wind. Take, however, a long, narrow building, or a building with a deck, and they need bracing against wind pressure.

In the case of a long building with the gables at the end, and where the roof starts above floor, there is nothing to prevent the rafters moving transversely to the building and parallel to each other when the rafters are only tied by collar beams. Such a roof very much resembles the ordinary railroad bridge trusses in principle of lateral pressure. An equivalent to the diagonal bracing of the horizontal panels in these bridges is all that is needed here. This may be accomplished by dividing the building lengthwise into approximately square panels, then laying joists flat on the top of the collar beams, so as to form diagonals to these panels, and then spiking them to every collar beam. This construction may of course be varied for special cases.

In deck roofs our problem is very much that of the ordinary trapezoidal truss, which is perfectly stiff under dead weight, but liable to give under wind pressure. If we tie the angles of the trapezoid there is no chance for it to change its form, provided, of course, that our timbers are heavy enough not to be affected by what little bending moment is brought upon them by this operation. I have put up quite a number of roofs leaving a clear attic or barn loft, and by using the precautions mentioned, varied to suit each case, have found them perfectly stiff, making the building more convenient and appearing much better inside. Now that we are on the roof I think it is as good a place to stop as any, leaving you to get down as best you may.

RITTER'S PERSPECTOGRAPH.

THE accompanying engraving (Fig. 2) represents an apparatus which is designed for quickly putting architectural drawings into perspective, and which is the invention of Mr. Hermann Ritter, who recently presented it before the Society of Architects and Engineers of Frankfort-on-the-Main.

Say we wish to put into perspective a plane figure situated in the plane r r' S S' (Fig. 1). The eye of the spectator

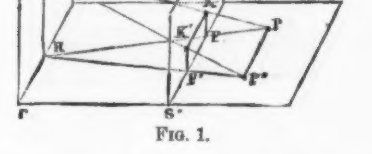


FIG. 1.

is at H, S S' is the trace of the plane of the perspective called the picture, r r' is the trace of a parallel plane passing through H, and H R is a perpendicular to r r'. The points P and P' have K and K' for perspectives, and H R remains constant.

Let us refer to the figure of the instrument: A plan drawing is glued upon a board which will be taken for the plane of the lines of a horizontal course whose perspective is desired. The ruler, s, occupies the position of S S' in the diagram shown in Fig. 1, and the same is the case with the ruler, r r', and the fixed point, R. The point H is fixed at a distance from R that corresponds to H R of the diagram. At the points of juncture, P, of two rulers that are capable of sliding and revolving upon the fixed points, H and R, there is fixed a pencil which follows the contours of the horizontal line to be put into perspective.

In a slot in the ruler, P R, at its intersection, F, with s s', there moves a button which is fixed to a wooden slide movable in the axis of s s' and carrying a joint, f, at its other extremity. The intersection, K, of P H and s s' is connected in a like manner with a metallic rod, which is also in the axis, s s', and carries at the other extremity the joint, k, of the parallelogram, f c k c. The movements of F, and consequently those of f, therefore exactly follow those of the point, F, of the diagram. The variations of F K, corresponding to the ordinate, F K, of the perspective of the point, P, upon the diagram, will produce equivalent movements of k.

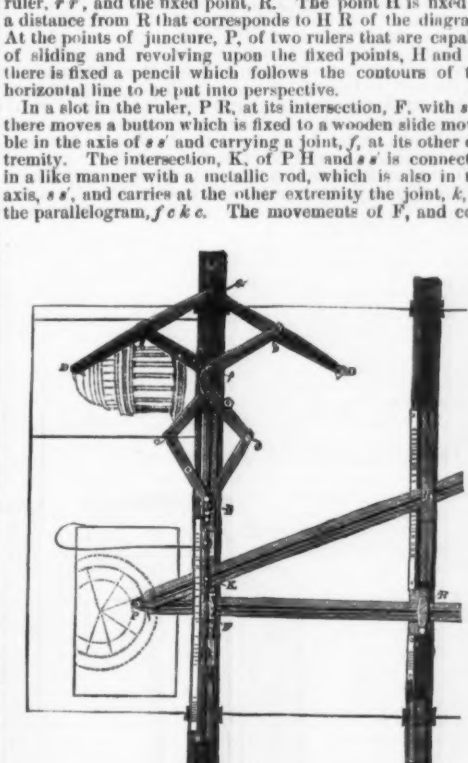


FIG. 2.—RITTER'S PERSPECTOGRAPH.

A second parallelogram, f b a b, whose sides, f b, are equal and perpendicular to the sides, f c, carries a fixed joint at a. The sides, a b, are prolonged to D by a distance equal to their length, and D carries the pencil which traces the perspective of P. As the two parallelograms, which are lozenges, are constantly equal, it will be seen that the ordinate, D f, will undergo variations equal to the movements of the points, k and K, with respect to F.

We have thus realized the condition that the foot, f, of the ordinate of the point, D, and the ordinate, D f, itself, both undergo exactly the same motion and the same variation in length as the point, F, and the ordinate, F K, of the diagram. D will therefore trace the perspective of the

points, P. When we have thus obtained the perspective of the different lines of the same horizontal plane, we pass to another plane in moving H a distance equal to that of the planes.

All the horizontal lines being thus traced, the vertical ones are to be drawn by hand.

It goes without saying that if the vertical lines predominate (as in a monument of Gothic architecture), we will start from a drawing in elevation and finish the horizontal lines by hand.

The second point, D, will trace the specular of the perspective.—*Le Génie Civil.*

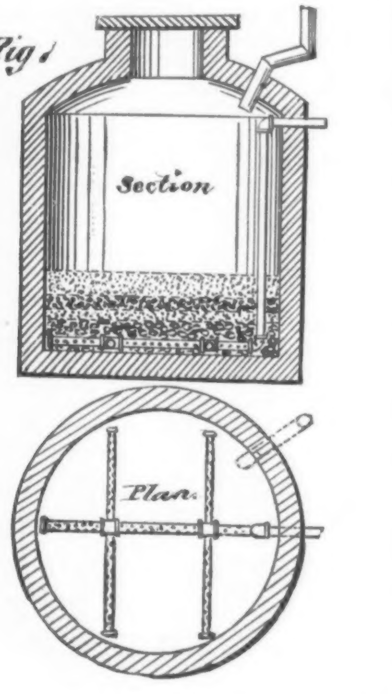
FILTERING CISTERNS.

By G. D. HISCOX.

FOR the instruction of a large and increasing population that are more or less dependent upon cistern water for culinary purposes, and also in many parts of the United States or in foreign countries where there is nothing but rain water available for human thirst, we have prepared a few illustrations of the most approved forms and materials for filtering rain water that is stored in cisterns, especially for drinking and cooking purposes.

Among the things to consider in determining whether cistern water is safe to drink, are the cleanly or dirty condition of the roof, and the materials it is made of; whether leaves from overhanging trees fall upon the roof and lodge in the gutters; whether birds foul the roof; whether it is made of wood, slate, or tin, or of materials inimical to health—as lead, copper, or covered with deleterious paints.

Fig. 1



The water taken from a cistern fed from a roof encumbered with leaves from an oak tree has been found so strongly impregnated with tannic acid as to turn water black when boiled in an iron pot.

In order to obtain the best results from filtering cisterns, the roof and gutters should be kept free from leaves and dirt, and it is also advisable to arrange the leader with a switch valve, with the handle convenient for operating within the building, so that the first wash may carry away the dust, dirt, or other foul matter, and thus save only the best water.

Caution should be exercised in locating cisterns that are intended to furnish drinking and potable water, that they be away from the influence of cesspool and privies, as clean water readily absorbs the odors, gases, and germs of foul air.

The materials selected for filter beds should be in accordance with the resources of the locality in which the filter is to be used, for the purpose of renewal.

We recommend such materials only as have proved reliable, leaving out all textile or organic substances, as we deem such unfit for this class of filtration.

Pulverized charcoal mixed with sand, or between layers of sand and gravel, so long used for filtering purposes, has a cleansing or antiseptic power, probably derived from the contact of a large carbon surface. Pulverized coke has been used, and is considered a fair filtrant, but less effective than charcoal. Bone charcoal has also been recommended as being highly antiseptic, besides having a strong absorbent power, due to the variety of its chemical components. It can be obtained from the dealers in New York.

Spongy iron, or pulverized hematite mixed with sawdust and roasted; pulverized magnetic iron ore and clean scale from a blacksmith's anvil, pulverized and mixed with clean, sharp sand, have been much used and experimented with in Europe with great success, in not only making fetid water sweet, but it is also claimed that the iron mixtures destroy bacteria and their germs.

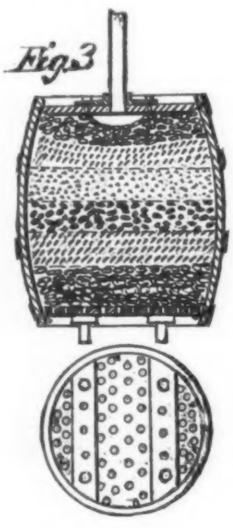
A combination of two extremes, a large carbon surface in charcoal and the pungent oxidizing qualities of the spongy iron, or its equivalents, will no doubt become the acme of a filter.

From experiments made with the filters of public water works in Europe, for the quantity of water that a filter will yield per square foot of surface, it has been ascertained that, with a filter composed of 10 parts fine sharp sand, 1 part coarse sand, 15 parts spongy iron mixed with one-third its bulk of fine gravel, laid upon a strainer of perforated galvanized iron—a bed of brick laid close—or a stratum of gravel covering a perforated iron pipe, a yield of one gallon of clear, pure water for each foot in depth per hour for each square foot of surface; four feet being the greatest depth with a yield of four gallons per foot per hour—illustrating the probable fact that the velocity of the water corresponds with the depth of the filtering material for equal purity.

Figure 1 illustrates a method of preparing an ordinary house cistern for filtering. The pipe and fittings should be of galvanized iron; black or plain iron is better as long as it lasts, as it rusts fast; in either case it is better to waste the water first drawn, for the water absorbs both the zinc and the iron when standing over night. The zinc is not healthy, and the taste of the iron is unpleasant.

The perforations should equal three or four times the area of the suction pipe, which in ordinary cisterns may be $1\frac{1}{4}$ inch pipe, while the branches may be $\frac{3}{4}$ inch pipe. The holes, if $\frac{1}{8}$ inch, should number at least 200, distributed along the lower half of the pipes. Smaller holes are preferable; of $\frac{1}{16}$ inch holes 800 will be required.

Fig. 3

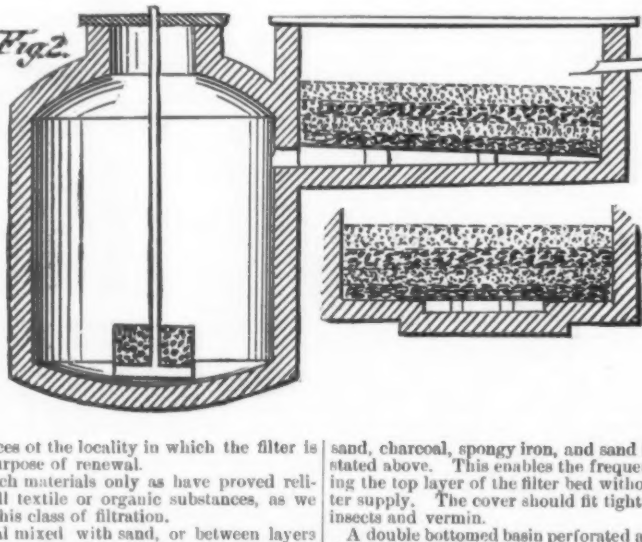


For the filtering material we recommend a layer of fine gravel or pebbles for the bottom, 3 or 4 inches in depth, or heaped up over the perforated pipes; upon this a layer of sharp, clean sand, 9 inches in depth; upon this a stratum of pulverized charcoal, not dust, but granulated to size of peas or beans, or any of the material above mentioned, 4 inches deep; and upon this a stratum of fine, clean sand from 6 to 2 inches in depth, making a total depth of from 16 to 20 inches.

Such a filter should be cleansed at least twice in a year by pumping out all the water, taking out the mud or settlings, and one-half the depth of the top layer, and replacing with fresh sand.

The double filter cistern, Fig. 2, has much to recommend it, having a large receiving basin which in itself is a filter placed in a position for easy cleaning. The recess at the bottom may be covered with a perforated plate of galvanized sheet iron, upon which may be laid a filter bed of gravel, sand, charcoal, spongy iron, and sand in the proportions as stated above. This enables the frequent cleaning by removing the top layer of the filter bed without disturbing the water supply. The cover should fit tight enough to keep out insects and vermin.

Fig. 2



A double bottomed basin perforated and filled with clear, sharp sand and charcoal should be attached to the bottom of the pump pipe, as shown in Fig. 2.

This enables the small filter to be drawn up and cleaned, without the necessity of emptying the cistern or interrupting the water supply.

The half barrel or keg filter, as illustrated in Fig. 3, is a convenient form of cistern filter where filtered water is required from cisterns already filled.

This is also a convenient form for readily cleaning or changing the filter without the necessity of discharging the water from the cistern.

This filter can be made from an oak keg or half barrel, such as is used for liquors or beer. Take out one of the heads and cut away the edge, so that it will just drive into the end of the keg, fasten two battens of oak across the head with oak pins left long enough to serve for legs for the filter to rest upon.

Bore this head full of holes one-quarter inch diameter. In the other head bore a hole $1\frac{1}{4}$ inches diameter, and bolt an iron flange into which the pump pipe is to be screwed. Let the bolts also fasten upon the inside a raised disk of galvanized sheet iron, perforated with a sharp point or chisel. Proceed to charge the filter by turning the top or flanged head down, and placing next the perforated plate a layer of fine gravel 3 inches thick, then a layer of sharp, clean sand 3 inches thick, then a layer of pulverized charcoal free from dust, 3 inches thick, then a layer of sharp clean sand mixed with spongy iron, pulverized magnetic iron ore, or blacksmith's scales, followed by a layer of coarse sand, gravel, and broken stone, or hard burnt bricks broken into chips to fill up. Place the perforated bottom in as far as the head was originally; bore and drive a half dozen oak pegs around the chine to fasten the head. Then turn over the filter, screw the pump pipe into the flange, and let it down into the cistern.

Such a filter requires to be taken out and the filtering renewed in from 6 to 12 months, depending upon the cleanliness of the water catch. With the precautions mentioned above in regard to the care of the roof, such a filter should do good work for one year.

GILDING.

THERE are many processes of gilding, varying with the nature of the substance to be gilded and the kind of effect required to be produced, but they may all be classified under three heads, namely, first, mechanical gilding; second, chemical gilding; third, encaustic gilding.

The first is used chiefly for gilding wood, plaster of Paris, leather, paper, and other substances. If the object to be gilt is a picture or mirror frame, consisting of a plain wooden moulding, then, after getting a coat of oil paint, from four to ten coats of fine whiting mixed with fine glue are put on, each in its turn being smoothed with pumice stone and fine sand paper. This done, a coat of gold-size is given to those parts which are not to be burnished; but those which are, receive only a coating of clear animal size. Both of these prepared surfaces receive the gold leaf, which is laid on by means of a broad thin brush called a tip, and further pressed on with a thick soft haired brush. Those parts which have been gold sized are in this way oil gilt, and will stand washing; while such portions as have been gilt on the size preparation in order to be burnished, will not bear soap and water. If the picture frame is much enriched with raised ornaments, then the various coatings of whiting are not smoothed with the pumice or sand paper. In many cases, and especially with outside work, the surface to be gilt is previously prepared with oil paint and gold size alone. The gold size used for oil gilding is of different kinds. Sometimes it consists of boiled linseed oil and ground ocher alone. Another kind has copal varnish and turpentine in addition. Japanners' gold size is a mixture of $\frac{1}{2}$ lb. of linseed oil, 2 oz. of gum anime in powder, and some vermilion.

Where gilt ornaments are to be put on a japanned ground, they are by one method painted with gold size, and gold leaf afterward applied. By another way, rather more than the space the ornament is to occupy is wholly covered with gold leaf, adhering with isinglass. The ornament is then painted on with asphaltum, which protects the gold beneath it while the superfluous leaf is being washed away. A little turpentine will then remove the protecting asphaltum so as to display the gilt ornament.

False gilding, although an old invention, has become in recent years an important trade in Germany. It is usually applied to mouldings for pictures, mirrors, and room decoration. The moulding intended to be "gilt" in this way is first covered with silver leaf or tin foil on a surface prepared as above, and then coated with a yellow varnish. A cheap and very durable imitation of genuine gilding is thus obtained, with which most of the less costly picture frame mouldings are now covered.

Metals are now usually gilded by the process of electro gilding, but, besides this, various methods of chemical gilding have been adopted, and some are still in use.

Water or wash gilding, as it is somewhat inappropriately termed, consists in applying to metal a paste formed of an amalgam of gold, and afterward evaporating the volatile mercury by heat, which leaves the gold firmly adhering to the surface of the metal. In preparing the amalgam, about eight parts of mercury to one of gold are used, but when this is squeezed through chamois leather some mercury is removed, so that the amalgam actually applied contains about 33 per cent. of gold. The metal to be gilt is cleaned with acid, brushed, and rubbed with bran or sawdust to make its surface perfectly clean. By means of a wire brush a solution of nitrate of mercury is then applied to it along with a portion of the gold amalgam. The mercury is driven off by heating at a charcoal fire, and the gilt surface is then ready for burnishing, which is done by rubbing it with a hematite burnisher. The deadening is produced by coating the surface with a mixture of sea salt, niter, and alum, and applying heat. Although modern appliances have diminished the evil, water gilding is still injurious to those who work at it, from the effect of the mercury fumes. It is worth noticing that this old process of gilding, although the contrary is often believed, is really better and more durable than electro gilding. It is asserted that to the introduction of the latter method is to be attributed the decline of the once prosperous gilt button trade; at all events, the more costly kinds of decorative work in metal are now gilt as of old by the mercury process. Thirty thousand buttons, one inch in diameter, may be gilded with one ounce of gold; fourteen or fifteen thousand is the number over which the quantity is commonly spread.

For gilding by immersion a solution is used which slowly attacks the metal to be gilded, and at the same time deposits on its surface an equivalent of gold. Elkington's patent solution is made by dissolving $\frac{1}{4}$ ounce troy of fine gold in $2\frac{1}{2}$ ounces of nitro-muriatic acid, heating this until red and yellow vapors cease to be evolved, then diluting with $1\frac{1}{2}$ pints of distilled water, adding to this 1 pound of bicarbonate of potash, and boiling for two hours. The article to be gilded is dipped into this at nearly the boiling heat, and agitated in it for about a minute. Talbot's patent solution is made by adding a solution of gold to a solution

of gallic acid in water, alcohol, or ether. The articles are dipped as above.

The method called Grecian gilding is a process intermediate between the above and water gilding. Sal ammoniac and corrosive sublimate are dissolved in nitric acid, and gold is dissolved in this solution, which thus becomes a mixture of chloride of gold and nitrate of mercury with some ammonia. This solution, on being applied to a surface of silver, immediately blackens it, but upon the application of heat it is richly gilded.

Most articles that are gilded by either of the above chemical methods, or by electro gilding, are submitted to an after process of coloring. This consists either in acting upon the surface with a saline solution, and heating the article afterward, or in coating it with a kind of varnish of bees-wax and yellow ocher, and then burning it off. Various saline solutions are used, many of which are carefully guarded trade secrets. 1 oz. alum, 1 oz. common salt, and 2 oz. niter dissolved in half a pint of water is recommended. Also 24 parts of niter, 10 alum, 5 sulphate of iron, 5 sulphate of zinc, boiled together in sufficient water to form a paste when cooled, with continual agitation. The articles are immersed in this, and then heated till the desired color is obtained.

For cold gilding a gilding powder is first prepared by dissolving 5 drachms of pure gold and 1 drachm of copper in 10 oz. of nitro-muriatic acid, then moistening clean linen rags with the solution, and burning them to ashes. These ashes contain finely divided gold, which may be applied to surfaces of copper, brass, or silver, by simply rubbing it over them with a piece of cork moistened with a solution of common salt in water.

Sword blades, lancets, and other steel articles are gilded in fancy devices by drawing the design with a camel's hair pencil moistened in a solution of gold, prepared by agitating ether with a solution of terchloride of gold, and decanting the light liquid which floats on the top. Steel or iron can be gilded in a more durable manner by heating it and then applying gold leaf.

Silks, artificial flowers, ivory, bone, etc., may easily be gilded by immersing them in or painting them with a neutral solution of 1 part of terchloride of gold to 4 or 5 of water, and then exposing them in a vessel containing hydrogen gas, which readily combines with the chlorine, and reduces the gold to the metallic state.

Encaustic gilding is usually applied to glass and porcelain. The gold is first obtained in a finely divided state by precipitating from the chloride with protosulphate of iron, or by simply heating the chloride. This powder is ground up with $\frac{1}{12}$ of its weight of oxide of bismuth and some borax and gum water, and then painted on the ware. It is heated till the borax is vitrified and the gold thereby fixed. Sometimes the gold is ground with turpentine, or an amalgam of gold is used. It has a brown dingy appearance when it leaves the kiln; the gold luster is brought up by burnishing.—*Glassware Reporter.*

BASIC REFRACTORY MATERIALS.

ABOUT two years since the Verein zur Beförderung des Gewerbfleisses (Berlin) offered a prize for the best paper on the properties of basic refractory materials, a subject which was just at that time attracting unusual attention on account of the introduction of the Thomas-Gilchrist-Snelus-Bessemer process. The prize has been awarded to Herr A. Wasum, of Bochum, whose paper has been printed in the transactions of the society, and a translation of which appears in the *Engineering and Mining Journal.*

Lime and magnesia are in themselves as refractory as the best other materials, not a trace of melting being shown on pieces exposed to the highest temperatures of steel-melting furnaces. It is a different matter, however, when lime and magnesia are subjected both to chemical action and elevated temperatures.

Herr Wasum made a series of experiments, his main aim being to imitate as closely as possible the conditions of actual practice. He made bricks of dolomite, lime, magnesia, and magnesite, using different binding material and additions, whose action upon the base was to be examined. These bricks were pressed with as little water as possible, in iron moulds, dried, and were then exposed to the highest white heat attainable in kilns used for making basic Bessemer brick, the shrinkage being simultaneously noted. A part were kept in the dry air, in order to test their resistance to disintegration.

A second set was heated to redness, when red-hot was cooled in water, and was then kept in the air until it disintegrated; while a third set was treated in the same manner, but, after cooling in water, was again heated to redness, and this kept until the brick fell to pieces. The crude materials used had the following composition:

	Dolomite. Per cent.	Magnesite. Per cent.
Lime	31·62	1·69
Magnesia	20·19	44·98
Silica	1·70	0·10
Alumina	0·09	0·84
Protoxide of iron	1·22	1·63
Protoxide of manganese	Trace	0·29
Carbonic acid	43·35	50·57
Total	100·17	100·00

	Limestone.
Carbonate of lime	98·80
Insoluble residue	1·07
Total	99·87

The magnesia was prepared by burning the magnesite at a white heat.

In all, 71 experiments were carried out with each of these four materials, in order to test the action of clay (with 49·4 per cent. silica), silica, phosphoric acid, oxide of iron, sesquioxide of iron, sesquioxide of manganese, and a basic converter cinder.

The latter had the following composition: 8·14 per cent. of silica, 48·25 per cent. of lime, 4·65 per cent. of magnesia, 15·84 per cent. of phosphoric acid, 9·48 per cent. of protoxide of iron, and 6·14 per cent. of peroxide of iron. In the case of dolomite the investigation embraced experiments on the action of protoxide of iron, phosphate of protoxide of iron, and phosphate of peroxide of iron. Herr Wasum has tabulated the results, and draws from them the following conclusions:

1. *The Manufacture of the Brick.*—Good brick may be made of dolomite, limestone, and of magnesia burnt at a white heat, without the addition of any binding material. This, however, is not the case with magnesite, because the latter, when ground, is not sufficiently plastic. Much finer brick are obtained when clay is added; and under these conditions, even magnesite yields faultless brick. Unless the new material used for the manufacture of the brick is very inferior, the addition of clay may go as high as 5 per cent. without materially affecting the refractory character of the brick. They must be burnt at the highest white heat for a long time.

2. *The Action of Air upon the Brick.*—Dolomite and lime brick, made without any binding material, will, on an average, last three weeks in dry air. By the addition of clay, their durability is materially increased. Brick made of magnesia or magnesite, with or without clay, last more than three months. The temperature at which the brick have been burned greatly influences their durability. The higher it has been, the better the brick in this respect. In practice, brick from the same kiln will show marked differences in regard to resistance to weathering, a fact attributed to differences in the temperature of burning. It is important, therefore, in designing the kilns, to have the flues so arranged that the temperature is uniform throughout the entire kiln.

3. *The Durability of the Brick after Cooling with Water.*—Dolomite and lime brick, cooled with water when red-hot, fall to pieces very rapidly; but this disintegrating process is much retarded by adding clay in their manufacture, in direct proportion to the percentage added. When the brick are, after cooling with water, reheated to redness, they do not entirely recover their resistance to weathering, but it takes a few days longer for them to disintegrate. Cooling with water has little effect on magnesia and magnesite brick. They had not fallen to pieces after they had been kept a year. More or less all basic brick crack by cooling in water when red-hot, but these cracks are rarely so large that they break at once. When, however, disintegration sets in, the brick split in the direction of these cracks, generally, in conformity with their form, at right angles to their two axis. In the case of magnesia and magnesite brick, also, a slight disintegration is noticeable, it being possible, after a few months, to break them by strong pressure of the hand in the direction of these cracks. The surface of these cracks is dull, while the fracture of the brick is otherwise brightly crystalline.

4. *Shrinkage in Burning.*—Dolomite, lime, and magnesite brick, unless made of impure material, shrink about 24 per cent. when exposed to the highest white heat. Brick made of strongly calcined magnesia shrink only 4 per cent. All substances that tend to decrease the refractory character of basic brick increase their shrinkage.

5. *Action of Acids and Metallic Oxides Formed in Metallurgical Processes.*—Lime and dolomite brick are equally attacked by the cinder formed in metallurgical processes, while magnesia brick show much more resistance. The oxides of iron are the worst enemies of basic brick, and therefore particular pains must be taken in choosing raw material, with the view of having them as free as possible from oxides of iron, which make the brick less refractory without at the same time increasing their durability in dry air. Silica, phosphoric acid, and the oxides of manganese are not so destructive to basic brick.

Summarizing, Herr Wasum states that undoubtedly the best material for basic brick is magnesia preheated at the highest white heat. The brick made from this material are remarkable for their durability in dry as well as in moist air, for their power of resistance to the action of cinder at high temperatures, and for the small amount of shrinkage.

One great practical drawback of the lime and dolomite brick is, that they disintegrate in so comparatively short a time, so that it is impossible to manufacture a large stock of them. The heavy shrinkage, too, is disagreeable, leading to the production of very many irregularly shaped brick, and causes large joints in the masonry, which in turn lead to its rapid destruction.

All these drawbacks disappear with the magnesia brick. Notwithstanding this, their cost excludes them, and they would be available only if, at present prices, they would last from three to four times longer than lime or dolomite brick. Practical experience has shown, however, that their resistance to the action of cinder is not much greater.

ALUMINUM MORDANTS.

ALUMINUM in the shape of the alums is certainly the oldest and most widely spread mordant. The alums are double salts containing aluminum sulphate and some other sulphate such as that of potassium, ammonium, chromium, etc., together with twenty-four molecules of water of crystallization. In ancient times the useful properties of alum were well known, and it was much used in dyeing and tanning. Nowadays, however, it is considered by authorities that the "alumen" of Pliny was really copperas, but this is not quite certain.

The most injurious impurity in alum is iron, especially as the very smallest traces of this metal must reduce its value for most of the purposes to which it is applied. The best test for iron is the yellow prussiate of potash, which gives a deep blue precipitate of Prussian blue. In order to distinguish ammonia alum from potash alum, boil a sample with a little caustic alkali. In the case of the ammonia alum a strong smell of ammonia will be observed. Twenty-five years ago ammonia alum was very much used, but has now become rather rare in the market. At present the favorite alum is the so-called Roman, although it almost invariably contains iron. However, the iron is generally in the state of ferric oxide, which is insoluble in water, and hence can be easily removed.

In the presence of ferric oxide the alum is always more or less colored. Roman alum frequently contains some basic alumina sulphate, and this improves its mordanting properties. Basic alumina sulphate can be prepared by the addition of ammonia or potash. Cubical alum is obtained by heating a solution of potash alum with one-twelfth of lime at a boiling heat.

The lime is taken on the alum in solution, and the resulting crystals are cubical, whence the name. The affinity of the mordant for textile fabrics is much increased by mixing potash, soda, or the carbonates of the same with the alum mentioned. Double or patent alum differs from the ordinary compound in not being a double sulphate, but simply alumina sulphate.

In this form the dyer obtains the maximum amount of the active ingredient, and hence this preparation is rapidly gaining ground. The disadvantages are that it is not in the form of crystals, and hence its composition varies. Also free acid and excessive quantities of iron are not rarely present, and of course these may be fatal. Improved methods of manufacturing are, however, coming into use, and no doubt we shall shortly be able to buy the article free from iron and uncombined acid.

Next to alum the acetate of alumina is of the most importance, being much used in coloring cotton, but rarely for animal fibers. This mordant is mostly prepared from sugar of lead or acetate of lime by double decomposition with alumina sulphate. The following is a favorite recipe for red liquor for steam alizarine red:

Alum	68 lb.
Water	100 galls.

Add 62 lb. crystal soda in 150 gallons of water.

The precipitate is washed three times by decantation and is then dried on a cloth filter. Dissolve 30 lb. of this product in six quarts of acetic acid of 11½° Tw. Heat to 32° C., and keep at this temperature until solution is complete. Filter, and then let down with water as required. Usually 100 parts of alizarine paste require 30 parts of the above mordant at 17° Tw.

For "Rose Bengale," mordant the yarn in Turkey red oil 1:20 and dry. Run for two hours through the mordant at 3° Tw.; rinse, and dry in half an ounce of "Rose" and three-quarters of an ounce of acetate per 2 lb. of yarn. Temperature, 44–60° C. The mordant is got by mixing:

Alum	3¼ oz.
Lime Acetate	1⅞ oz.
Water	17¼ oz.

Settle, decant, and ready.

Some practical dyers state that the presence of lime acetate in an alumina mordant is of benefit. Aluminum nitrate is also in use, but more rarely. It is best prepared by double decomposition from nitrate of lead and patent alum. The precipitated lead sulphate is removed by decantation. An aqueous solution of aluminum chloride is employed to a limited extent.

It is generally made by dissolving ammonia alum in muriatic acid or else by decomposing patent alum with calcium chloride. Fourmier's specification directs the solution of patent alum to be mixed with common salt and exposed to a temperature of from 0° C. to 2° C. Glauber salt crystallizes out and chloride of aluminum remains in solution. Professor Kopp proposed the employment of aluminum thiosulphate, prepared by double decomposition from thiosulphate of lime and patent alum. Although Kopp states that this mordant has great advantages over the acetate, English practical dyers have as yet not been at all able to indorse that opinion. *Alumina orealate*, prepared by dissolving alumina in oxalic acid, has not come in general use. *Aluminate of soda* contains alumina in the shape of an acid as it were combined with the soda, and is made by dissolving alumina in caustic soda.

It is a commercial article in the solid state, and is frequently met with almost pure. By means of this mordant some colors can be got which it is impossible to obtain with alum, and in spite of its alkalinity it can be used for mordanting wool.

In calico printing aluminate of soda is used for pale pinks, this bath being followed by sal ammoniac or zinc chloride. The world's total annual consumption of alum is estimated at 10,000,000 kilogrammes, of which Germany furnishes 3,500,000 k.; Austria, 2,000,000 k.; Spain, 1,500,000 k.; Belgium, 800,000 k.; Russia, 50,000 k.; England, 600,000 k.; Italy, 500,000 k. Turkey possesses alum mines, but their production has gone down, as has that of Sweden and Denmark. The most expensive alum is the so-called Roman, and the cheapest the Spanish. Besides being extensively employed in textile coloring it is much used in tanning, paper making, baking, medicine, etc.—*Das Deutsche Wollengewerbe.*

RESTORATION OF FADED PHOTOGRAPHS.

WE have been favored by Mr. E. Poole, of Saint Catherine's, Ontario, with an opportunity of examining a very bad example of faded photograph which has fallen into his possession; it is accompanied by a request that we would make it the groundwork of a few remarks. The portrait is of a somber yellow color throughout, the blacks and shadows differing from the lights only in the yellow being of a slightly deeper tone. This is a charmingly pronounced case of fading, and well worthy of the remarks craved for.

When a photograph fades in the manner or to that extent described, it is an indication of its being sulphur toned, perhaps not exclusively so, but in a great degree. If such a photograph be brought for restoration, the first thing to be done is to make a copy of it by the camera. The negative thus obtained may be very feeble, and doubtless will be so; but so long as the detail shown in the original is there, want of vigor is of no consequence. From this negative a transparency is made. By giving only a brief exposure and forcing the development, the transparency will be far stronger and more vigorous than the original. Not until this transparency has been carefully retouched, and the expression compared with that of the portrait from which it was copied, must this latter be subjected to the process of restoration. The object of making the transparency is to effect a species of insurance upon the original, because it is not every faded photograph that can be restored. Some not only cannot be rejuvenated, but they get destroyed in the attempt at restoration, and unfortunately it cannot be ascertained beforehand whether any special photograph will be restored or succumb in making the endeavor.

Place the faded photograph in water, which should be slightly warm. After a little time it may be stripped from off the mount. It is then laid, face down, upon a plate of glass, and every trace of paste washed carefully from off the back. When this has been effected, transfer the print to a clean porcelain dish, laying it face up, and then pour over it enough of a one-grain solution of chloride of mercury to cover it properly. This solution should not contain either hydrochloric acid or any of those chlorides by which the solubility of the mercurial salt in water is promoted, but should consist alone of say ten grains of bichloride of mercury, powdered, and added to ten ounces of slightly warm water, by which it will be speedily dissolved.

When this is poured over the print, a change will soon become apparent; the whites, which were previously of a dingy, sickly looking yellow, become pure, the blacks having a darker appearance by contrast alone. But not alone by contrast is vigor effected, for while the mercury bleaches the whites it also darkens the blacks. This would have left nothing to be desired, had the blacks assumed a dark purple hue similar to that produced by gold toning; but in almost every case the tone is that of a pinkish purple which is too warm and delicate to suit the generality of tastes.

In some cases, details which had for years been obliterated become again visible; and it is known that in one or two instances the restored print possessed a pluck and vigor greatly exceeding that which prevailed when the photograph was not a week old. The pink tint to which we have referred does not inevitably follow from restoration, for sometimes the blacks assume a deep purple brown that is quite pleasing.

It need scarcely be said that after the photograph has been restored it must be thoroughly washed, to eliminate the mercury from the pores of the paper, and then be dried in a current of air. Probably the most curious part of the affair is this, that a photograph which has been thus treated will not again fade; it is now permanent so far as concerns the action of air, at any rate. In our museum of old photographs, we have two stereoscopic prints, interiors of cathedrals, which in 1866 were treated in the manner described in consequence of their having faded badly, probably from imperfect toning. In their case the restoration has proved effective, seeing that they are quite as good now as they ever were, certainly as they have been since the treatment with mercury.

There is so much that is obscure concerning the precise composition of a faded silver image upon albumenized paper that we shall not at present enter into the chemistry of the restorative process. But from an experiment we have just made with a print carefully toned with sulphur alone, without gold, we incline to the belief that any attempt made to restore such a print by mercury, when faded, would result merely in bleaching it entirely, whereas in the case of a print in the toning of which gold was employed, there is a reasonable probability of its being restored by the mercurial treatment.

We are aware of faded prints having been successfully treated otherwise than by mercury; and we know that in some instances strength and vigor have been imparted to the blacks by the agency of gallic acid and citro-nitrate of silver; but we have not had such experience of these as would warrant our speaking of them at present.

If, in the case assumed, the restoration has been perfect, all is well; if it has proved a failure, then, from the transparency which was taken as a precautionary measure, a negative must be obtained by superposition, from which in turn may be produced prints which shall in each instance be a *fac-simile* of the original in all respects except its having faded. —*Photographic Times.*

SIMPLE PHOTO-ENLARGING APPARATUS.

WITH the introduction of gelatine sensitive silver paper, which has the property of being extremely sensitive to light, enlarged life-sized pictures may now be readily made in a few minutes with an artificial light at night. Expensive apparatus and lenses, such as are used in solar printing upon the common albumenized sensitive paper, are dispensed with, and in their place a simple camera or magic lantern with an ordinary lamp may be employed.

Gelatine paper may be obtained already prepared, is used in a dry state, is always ready for use, and will retain its sensitiveness for any length of time, so that it affords the photographer and amateur a ready means for quickly making positive prints, at any time.

Our engravings illustrate two forms of apparatus for exposing upon the sensitive paper. The upper engraving shows a photographic dark room separated by a partition from the exterior room.

Upon a table is placed a board on which a saddle slides back and forth. An upright frame is hinged to the upper side of the saddle, and when in use the frame is held in a vertical position by a flat metal latch as shown. At the upper end and in front of the frame is pivoted a board twice the length of the frame, provided at one end with a large rectangular opening covered with a ground glass, the ground side being set flush with the face of the board. The board revolves edgewise in a vertical plane, and is perfectly balanced. The small engraving shows the position of the board when folded up. Arranged upon the interior side of the partition of the room in front of the focusing board is a camera box made in two parts, the front portion, with the lens attached, sliding over the rear half, which is secured light-tight around a rectangular opening in the partition.

A short focus lens of the portrait combination type, provided with a diaphragm of an inch aperture, produces the best results.

The negative, with the film side toward the lens, is held in the slide in an inverted position, and is slid into the grooved frame upon the exterior side of the partition, as shown. This arrangement allows different sized negatives to be quickly and easily adjusted. On an adjustable shelf, which can be raised or lowered, is located the ground glass, kerosene lamp, and reflector. The center of the lamp flame reflector, negative, and the lens of the camera should be in one focal line.

The ground glass in front of the lamp diffuses the light equally over the negative; an ordinary magic lantern condenser may be used in place of the ground glass, thereby materially decreasing the time of exposure.

Our picture shows the operator in the dark room in the act of obtaining a focus; the room is supposed to be closed to all outside light except that which comes through the lens, and the enlarged image of the negative is seen very distinctly upon the ground glass of the focusing board. The saddle is moved back and forth until the correct focus is obtained, as, for instance, when the hair of the head or the pupil of the eye looks sharp and distinct.

The picture appears very soft, and viewed at a little distance shows a remarkably pleasing, crayon-like effect. The size of the enlarged image may be regulated by varying the distance between the lens and the negative. Our lower engraving illustrates the method of exposing the enlarged negative image upon the sensitive paper, showing how the operation can be carried on in one room. The amateur photographer only needs to provide a board having vertical wings or sides which fit tightly around the sides of the back of his camera, allowing the bed of the same to slide in and out easily. A frame holding the negative is secured to the back of the camera in place of the usual ground glass, the latter is suspended just back of the negative, and at the rear end of the wings is located the lamp with reflector inclosed in a metal box. The arrangement is clearly shown in the small cut.

Holes are made on each side of the lantern box at the top and bottom to admit a free circulation of air, and are protected from the light by interior deflectors. A door at the rear end of the box allows the lamp to be removed. A tin cracker box can be successfully arranged to hold the lamp.

The space at the top between the rear end of the camera and the top of the lantern box is covered by a velvet or other black cloth to exclude the light. As before stated, the center of the light, negative, and lens should be in one focal line.

Having obtained the correct focus on the ground glass on the focusing board, the operator covers the lens with a cap of ruby glass, turns the ground glass end of the focusing board up, and fastens on the lower portion, in proper position, the sensitive sheet. When the sheet is rightly located the hook may be unlatched and the board turned flat, as shown, so that the paper may be more easily pinned to the face of the board; the latter is again raised, secured, and made ready for the exposure. As a vignetted picture is the most pleasing, and can be easily made, the operator needs to provide before exposure a cardboard having a notched oval aperture which, during the exposure, is held between the lens and focusing screen as shown. Looking upon the screen the dull red enlarged image may now be seen, but the moment the exposure is made by removing the red cap from the lens, the picture becomes suddenly bright and brilliant. The operator then moves the vignetting card to and from the exposed sheet, thereby decreasing and enlarging the vignetting circle. In this way the beautiful soft blending so characteristic of vignetted pictures is easily produced. With a lamp like a No. 3 Leader kerosene burner, giving a flame about 3½ inches wide by 1½ inches high, and of about 26 candle power, an exposure of four minutes has been found sufficient. The exposure may be quickly stopped by replacing on the lens the red cap.

The exposed sheet, with the latent image impressed thereon, should now be removed to a light-tight receptacle, where it may remain ready to be developed at the convenience of the operator.

Full directions in regard to exposure, development, and fixing are sent by the manufacturers of this gelatine paper.

As the process is so simple and the manipulation so cleanly and easy, nothing could be more pleasing, interesting, and instructive to the amateur than to amuse himself by enlarging as described.

The pictures are permanent, possess a soft, crayon-like appearance, and when finished form a beautiful adornment for one's walls.

Gelatine rapid printing paper is likely, therefore, to come into extensive use, and we predict for it a brilliant future.

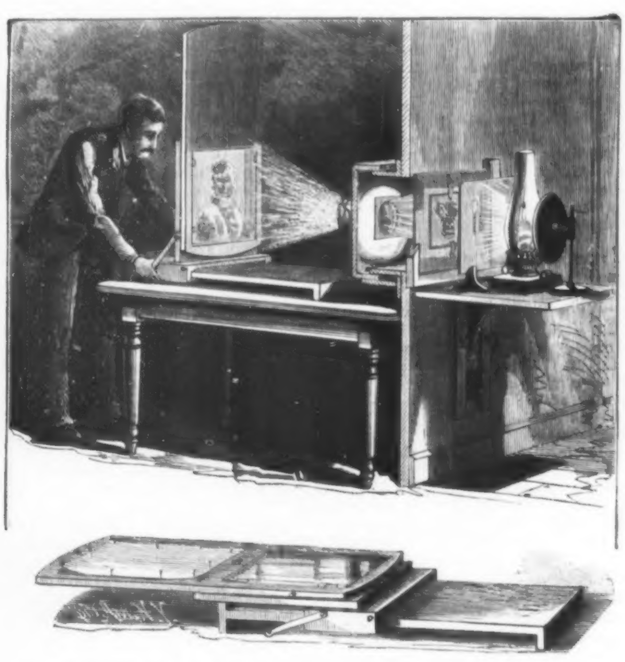


PHOTO-ENLARGING APPARATUS.—OBTAINING THE FOCUS.

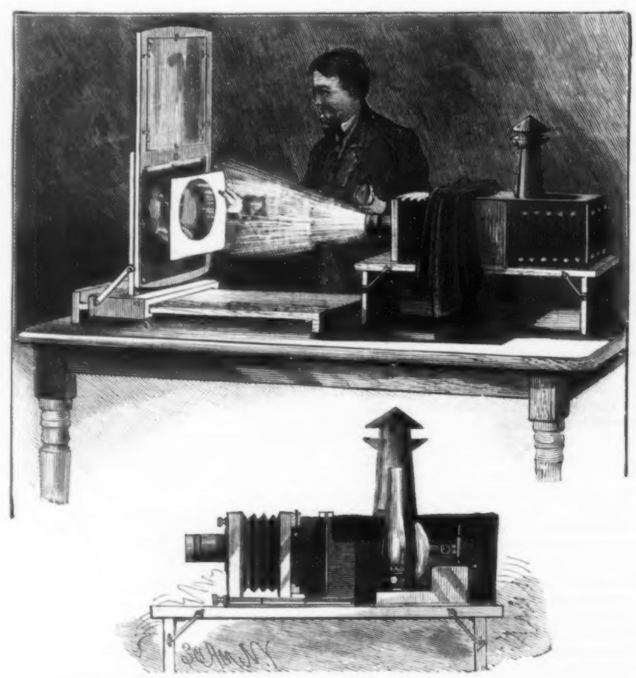


PHOTO-ENLARGING APPARATUS.—MAKING THE EXPOSURE.

WHILE the eucalyptus or Australian blue-gum tree destroys malaria and keeps off mosquitoes in marshy soil, it has no such effect upon dry soils. The difference is ascribed by a German scientist to the fact that the tree is constructed to act as an evaporating machine, and only does its work in marshy land. A feature of the tree is its adaptability to different climates, it being now grown in almost every civilized country where frosts do not occur.

HENRY WATTS, F.R.S.

WITH great regret we have to announce the sudden death or Mr. Henry Watts, on the 30th of June, of syncope of the heart. Mr. Watts was born in London on the 29th January, 1815. He was educated first at a private school in London, and subsequently attended lectures at the University College, London. In 1841 he graduated as Bachelor of Arts in the University of London. In 1846 he entered the Birkbeck Laboratory of Chemistry, then recently established at University College, as assistant to his highly-valued friend, the late Professor Fownes, and in that capacity was engaged in directing the work of the students till the death of Professor Fownes in 1849, and afterward till 1857 under Professor Williamson. In 1848 he was engaged by the Cavendish Society to prepare a translation, with additions, of the great "Handbuch der Chemie" of Leopold Gmelin, a work which extended to 18 volumes, and occupied a large portion of his time for more than twenty years, the last volume and index having been published in 1872. In 1858 he was engaged by the eminent publishers, Messrs. Longmans and Co., to prepare a new edition of Ure's "Dictionary of Chemistry and Mineralogy," but finding that this book, the last edition of which appeared in 1831, had fallen too much behind the existing state of chemistry to be made the groundwork of a dictionary adapted to the requirements of the time, he undertook, with the consent of the publishers, and the assistance of a staff of contributors distinguished for their attainments in different branches of physics and chemistry, the compilation of a new "Dictionary of Chemistry and the Allied Branches of other Sciences." This work, in five large octavo volumes, was completed in 1868, but as additions were required to keep it abreast of the continual advances of science, a supplementary volume was published in 1872, a second supplement in 1875, and a third (in two parts) in 1879 and 1881.

Mr. Watts also brought out three editions of "Fownes's Manual of Chemistry," viz., the 10th published in 1868, the 11th, in 1872, and the 12th in 1877.

He held for many years the appointments of editor of the *Journal* and Librarian to the Chemical Society, having been appointed to the former in 1850, and to the latter in 1861. He was elected a Fellow of the Chemical Society in 1847, a Fellow of the Royal Society in 1866, and a Member of the Physical Society in 1879. He was also an Honorary Member of the Pharmaceutical Society, and a Life Governor of University College.

He was engaged at the time of his death in writing a new and abridged edition of the "Dictionary of Chemistry." He was also editing a re-edition of "Richardson and Watts's Technology," and the 13th edition of "Fownes's Manual of Chemistry," of which the second volume is left in manuscript.—*Chem. News.*

PHYSICS AND CHEMISTRY.

1. *On the General Law of Solidification of Solvents.*—Raoult has studied the effect which is produced upon the point of solidification of a solvent by dissolving solid, liquid, or gaseous substances in it. If A represent the coefficient of depression, that is, the amount by which the temperature of solidification is lowered when one gramme of the substance is dissolved in 100 grammes of the solvent, M the molecular weight of the anhydrous substances, and T the molecular depression of the freezing point (that is, the depression corresponding to the solution of one molecule of the dissolved substance in 100 grammes of the solvent) then $MA=T$. The solutions employed were very dilute, containing less than one molecule (in grammes) of the solid to two kilogrammes of the solvent. The solvents used were water, benzene, nitrobenzene, ethylene dibromide, formic acid, and acetic acid, whose freezing points were respectively 0°, 4·96°, 5·28°, 7·92°, 8·52°, and 16·75°. The following are the conclusions reached: 1st. All bodies, whether solid, liquid, or gaseous, when dissolved in a definite compound liquid, capable of solidifying, lower the point of congelation. 2d. There is for each solvent a maximum molecular depression of the freezing point. And 3d. With all solvents, the molecular depression of the freezing point, due to the different substances dissolved, approximates to two mean values, differing with the character of the solvent, one of which is double the other.

Thus for ethylene dibromide these values are 117 and 58, for nitrobenzene 72 and 36, for benzene 49 and 24, for acetic acid 39 and 19, for formic acid 28 and 14, and for water 37 and 18·5. The greater of these two values, which the author calls the normal depression, is much the more frequent, ex-

cept in the case of water. Since, with the same solvent, the substances producing either the normal or abnormal depression belong to well-defined groups, the depression observed may be made use of in fixing the molecular weight. All salts of the alkalies, for example, when dissolved in water produce a molecular depression of about 37; hence among many multiple values of the molecular weight of such a salt, that one is selected which multiplied by the coefficient of depression of the salt in water gives a product nearest to 37. For organic substances soluble in water, that value is chosen which when multiplied by the coefficient of depression gives a value nearest to 18·5.

The foregoing facts seem to the author to justify the following generalization: For a constant weight of a given solvent, all physical molecules of whatever nature produce the same depression of the freezing point. When the bodies dissolved are completely disaggregated, as, for example, when they are in the state of vapor, so that each physical molecule contains only a single chemical molecule, the molecular depression is a maximum and the same for all bodies. When the chemical molecules are united in pairs to form the physical molecule, the depression has only one-half its former value, since the double molecule produces no more effect than the single one.

If the maximum molecular depression be divided by the molecular weight of the solvent, the quotient expresses the depression produced when one molecule of the substance is dissolved in 100 molecules of the solvent. This value is for formic acid 0·63, for acetic acid 0·65, for benzene 0·64, for nitrobenzene 0·59, and for ethylene dibromide 0·63; being practically the same for all. For water, however, the value is 2·61, a value four times too large. This the author explains by the hypothesis that the physical molecule of water consists of four chemical molecules.

The general law of solidification of solvents, Raoult enunciates finally as follows: If one molecule of any substance be dissolved in 100 molecules of any liquid, of a different nature, there is produced a depression in the freezing point of the liquid which is always about the same, and approaches very near the value 0·63. Consequently, the depression of the freezing point of a dilute solution, of whatever sort, is sensibly equal to the product which is obtained by multiplying the number 63 by the ratio between the number of molecules dissolved and the number of the dissolving molecules.

In subsequent papers, Raoult considers the application of this law to the study of the distribution of acids and bases in solution, and of the freezing point of acid and alkaline solutions. With reference to the latter, he concludes as follows: Acids and bases in this respect may be sharply divided into two groups. The first comprises those which produce a normal molecular depression of the freezing point near 40°. The second includes those acids and bases which produce an abnormal molecular depression near 20°. The bases of the first group are all analogous to potassium hydrate, and, like it, are capable of displacing from their chlorides all the bases of the second group. The acids of the first group are all strong acids like hydrochloric acid, and like it are capable of displacing from their alkali-salts all the acids of the second group.—*Ann. Chim. Phys.; G. F. B., Amer. Jour. of Science.*

ON DIFFERENT METHODS OF PRODUCING COLD ARTIFICIALLY.*

By J. J. Coleman, F.I.C., F.C.S.

An essential constituent of any machine hitherto used for producing cold continuously is an elastic fluid or vapor, which may be atmospheric air, ammoniacal gas, sulphurous acid gas, ether vapor, methylic ether vapor, etc., etc. Such vapor is alternately compressed and expanded, during which certain phenomena manifest themselves, and a succession of such constitutes the working of a machine for producing cold. If these cycles be studied, it will be found that they all involve introducing energy (in the form of heat, or its equivalent mechanical work) into the cycle, and then rejecting it; by this means the vapor is brought into that physically condensed condition by which it will absorb heat from an external substance by its own expansion or evaporation. A cold producing machine abstracts heat from the substance, being cooled by the spontaneous expansion or evaporation of an elastic fluid inside the machine; and to keep up a succession of such expansions and abstractions of heat from an outside body, heat or energy has to be given to the machines.

First let us take the production of cold by atmospheric air. In this case we have four distinct stages in the cycle, the first of which is that air is compressed by mechanical force or work, which not only compresses the air, but makes it exceedingly hot, for according to the laws of thermodynamics, 772 foot pounds of energy used in compressing the air appears as a unit of heat in the compressed air itself. The second stage of the cycle is therefore to get rid of this heat actually put into the air, and this is done by injecting into the air, well, river, or sea water, or by passing the compressed air through tubes surrounded with such water. This brings us to the third stage of the cycle, in which we have compressed air of atmospheric temperature. If we then make this compressed air work an engine constructed like a steam engine, it develops force and becomes intensely cold; and for every 772 foot pounds of mechanical energy developed, there is a reduction in temperature equivalent to one heat unit. We have now arrived at the fourth stage, which is, that the cold air is brought into contact with the substance we wish to cool, and goes back for another cycle. There is another way of producing cold by atmospheric air, known as the vacuum method, and it consists of three stages. In this case mechanical force is used to lift the piston of an air pump, the energy here being rejected in the friction or heat of displacing the atmosphere. The rarefied air inside the pump is made to pick up heat from the substance being cooled, and being restored to its normal pressure is expelled. When ether is used the cycle is as follows: By mechanical work the ether vapor is pumped from the reservoir of ether and then passed in a compressed state through pipes surrounded with cold water; here the energy introduced by the pump is rejected in the form of heat, which is carried away in the cooling water, the liquid ether then passes on into a reservoir, and then evaporates into the vacuum maintained by the pump; in fact, the ether evaporates so rapidly *in vacuo* that it boils at a temperature approaching zero Fah., and the liquid ether consequently abstracts heat from any substance we wish to be cooled by the machine. The cycle in the case of Pictet's sulphurous acid gas machine is precisely the same, only the whole apparatus is worked at higher pressure, owing to the boiling point of liquid sulphurous acid being lower.

Machines have also been introduced by Professor Linde, in which anhydrous ammonia is used instead of sulphurous acid gas; that is, ammonia gas absolutely free from water compressed by the mechanical force of a pump; the energy thus introduced is abstracted by passing the hot gas through pipes surrounded by water, and the liquid ammonia is then allowed to boil *in vacuo* created by the pump, which is at a temperature still further below zero than in the case of the sulphurous acid or ether, and thus abstracts heat from the brine or other liquid being cooled. The most common form, however, of the ammonia machine for producing cold is that introduced by Carre, and known as the ammonia absorption machine, and which has been much improved by Reece and others in this country. The cycle is very interesting to study. Ordinary very strong commercial liquid ammonia is put into a boiler of iron connected with an upright tower of shelves, a fire is placed under the boiler, and the mixed ammonia gas and steam ascend the tower; the steam condenses and drops back as water into the boiler, while the ammonia gas goes out of the top of the tower, and then descends through a coil arranged in a second tower filled with cold water; this cold water, of course, condenses the ammonia gas inside the tubes, which by this time has got, not only very hot, but very much compressed, there being a valve at the outlet of the coil which prevents the free flow of the gas, until by its accumulated pressure it liquefies itself. Comparing now this with the first two stages of the compressed air cycle, we have a repetition of the same phenomena. We impart energy to the gaseous ammonia, we abstract it again in the water cooling the coil of pipe. The product liquid anhydrous ammonia then goes to the next stage, where it is allowed to evaporate or expand spontaneously by release of pressure.

This evaporation is usually accomplished in a vessel containing pipes through which brine or other liquid to be cooled circulates. We now arrive at the fourth stage of the process, in which we have simply ammonia gas at atmospheric pressure, and in order to complete the cycle we have to make this gas come into contact again with water, and so become absorbed, and this is done in a fourth vessel in which heat is rejected, after which the reformed ammonia solution goes back to the boiler from which it started.

Another class of cold producing machine was devised by myself in the year 1876, and has been used on the large scale by Young's Paraffin Light and Mineral Oil Company for condensing volatile liquid hydrocarbons existing in the waste illuminating gas produced in distilling shale for oil. In this process energy was employed in compressing the hydrocarbon gases to a pressure of about 150 lb. to the inch; this energy was rejected by passing the compressed gases through a system of tubes, surrounded by cold water, a number of liquid hydrocarbons being thus obtained. The compressed gas was then passed through a second system of pipes, and then expanded in a cylinder, giving mechanical power to the crank shaft working the machine, the cold expanded gas being made to circulate around the second system of pipes, gave a second crop of liquid hydrocarbons (the product of joint cold and pressure), and consisting chiefly of amylene and other olefines, after which the gas was burnt as fuel.

Reverting to the definition with which I started, viz., that all cold producing machines involve introducing energy in the form of heat or mechanical work, and then rejecting the same before the vapor is brought into that physical condition that it will expand spontaneously each cycle, we may extend the definition, and state that spontaneous expansion involves the lifting of heat or energy from the substance being cooled, and transferring it (either as heat or mechanical work) to another body, and the extent to which this can be done in each cycle depends upon the energy introduced and then rejected in another part of the cycle.

A short time ago I had the honor of bringing this subject before the Institute of Civil Engineers in London, and in closing the discussion Sir William Armstrong made some remarks which will now be easy to understand. He said: "To the uninitiated a compressed air cold producing machine did appear to form an exception to the general rule that all mechanical energy is ultimately converted into heat, for it resulted in the production of an opposite condition; but looking a little more closely into the matter it would be perceived that the machine was really a heat producing machine, and that cold was merely the result of the fact that this heat was abstracted from the air, which thereby became a medium of refrigeration."

As atmospheric air is practically perfectly elastic, there is practically no limit to putting energy into it, and then removing the same, thereby increasing its density; consequently there is no practical limit to the cold capable of being produced in each cycle by the compressed air; but any machine which is worked through the medium of a readily condensable vapor, such as ammonia, ether, methylic ether, or sulphurous acid has its action limited by the boiling point of the volatile liquid; it is therefore impossible with such machines to get so large a range of cooling in one operation as can be accomplished by air. The low temperatures which Pictet required for the liquefaction of oxygen and hydrogen were obtained in stages, first by ebullition of liquid sulphurous anhydride *in vacuo* producing sufficient cold to liquefy carbonic acid gas at a pressure of four atmospheres, and then in taking advantage of the still greater cold produced by the ebullition of the liquid carbonic acid gas *in vacuo*. There is, however, no reason to suppose that the same or much lower temperatures could not be obtained by the compression and expansion of air in a single operation.

The boiling point of ether under ordinary atmospheric pressure is 95° Fahrenheit, so that in order to use it as a medium for refrigeration it requires to be evaporated *in vacuo*, that is, pumping is needed, which causes it to boil rapidly, and it becomes cooled as the vacuum is increased; but the cooler it becomes the more slower it evaporates, until, when its temperature sinks to a little below zero, evaporation ceases altogether, although the pump may be maintaining the vacuum. It follows from this that if the brine, which is usually the medium being cooled, returns back to the boiling ether without having picked up heat from the substance being cooled, the action is gradually diminishing. This phenomenon is very likely to occur when the brine cooled by such a machine is circulated in pipes through a chamber containing atmospheric air, more or less saturated with aqueous vapor, and as would actually be the case with a chamber containing fresh meat being cooled. The brine pipes under such circumstances become externally cooled, with a non-conducting covering of ice, having the appearance of enamel, which, unless removed, accumulates to the extent of several inches in thickness, thus interfering with the transfer of heat, and practically preventing the room from being reduced to a lower temperature than the freezing point of water, or the melting point of the exterior surface of the crust which surrounds the pipes, while the brine is liable to be returned back to the evaporating ether at much lower temperatures than it should for the economical working of the machine. The same remarks apply to the employment of sulphurous anhydride and of ammonia, the limiting action in the case of ammonia, which is considered the most effective in practice, being about 35° below zero of Fahrenheit when it is employed at atmospheric tension, as in Carre's process, or in Reece's process, though of course much lower when evaporating into a vacuum, as in Professor Linde's machine.

It is found, and generally admitted, that when an ammonia absorption machine is fresh started, it gives more economical results than any other machine when the work to do is cooling liquids or making ice; and in consequence of this fact ever since its introduction by Carre about twenty years ago, it has been tried by our leading brewers and others; but various difficulties have cropped up of a very serious nature in regard to its management—the most important being the fact that when the aqueous solution of ammonia is being heated for the purpose of expelling the gas from the water, more or less steam is carried forward through the system of coils and accumulates in the vessel, which should contain nothing else but anhydrous ammonia. Reece and other inventors remedied this defect to some extent, and this has been done by making the mixed ammonia gas and steam ascend a tower containing plates, arranged upon the principle of a Coffey's still, the water constantly trickling back. That an immense improvement has been effected is undoubted, and in consequence thereof leading brewers such as Meux & Co. and Charrington, Head & Co., of London, and Guinness & Co., of Dublin, have erected large machines. But, on inquiry, I find there is not that enthusiastic approval of them which indicates they have been a complete success. For instance, Messrs. Guinness & Co.'s engineer informs me that when fresh started the machines came up to calculations, but that for three seasons subsequently they could not get more than fifty per cent., and Messrs Meux & Co., although still working the machine, have actually since had erected an ammonia machine on the compression system, in which a steam engine is used; and in another part of their works they have recently adopted a cold air machine, designed by myself. Messrs. Meux & Co. state that one difficulty about the ammonia absorption machine is the large quantity of low temperature cooling water required to condense the ammonia vapors, partly from the steam accidentally produced along with it. In any case the ammonia gas requires to attain a considerable pressure before it liquefies in the coils surrounded with water; if the temperature is 60°, the liquefaction takes place at 120 lb. per square inch, but at 104° the liquefaction requires a pressure of 217 lb. per square inch. If the boilers containing the ammonia are in a warm climate, such as that of the tropics, the liquefaction is difficult; and a case was reported recently of the blowing up of such an apparatus, twenty-eight horses being suffocated by the fumes. These difficulties have induced New York brewers to try the compression system with ammonia, the liquefied ammonia being expanded in a network of pipes, not in the vicinity of the compressing pumps, but arranged on the ceilings of the storerooms, or within their vats, the expanded gas being carried back to the compression pumps. This is reverting to a steam engine as the motive power, and brings the ammonia process into the same category as the ether and sulphurous anhydride processes. In regard to the sulphurous anhydride process, backed up by the great name of Raoul Pictet, it has had some degree of popularity abroad, but has not made much progress in this country; it is a more troublesome substance to work with than ether, and under certain circumstances, leakage and contact with moisture is actually dangerous to the metallic surfaces of the machinery, some accidents having arisen from this cause.

The ether machine was introduced twenty-five years ago, and has had a long run, but although ether is not so difficult to prepare for using in the machines as liquid sulphurous acid or anhydrous ammonia, it is not convenient for use in hot climates, on account of the lowness of its boiling point as compared with the heat of tropical countries.

Theoretically, according to the laws of thermo-dynamics, it is immaterial which chemical be employed, but the bulk of the machines, and the nature and cost of their construction, differ according to the substance selected.

The advocates of these various chemical machines have been so decided in their statements, that for purposes outside the cooling of rooms, or the carrying on of the frozen meat trade, I have not until recently thought of recommending compressed air machinery for general purposes, such as that of breweries. The well known firm of Wm. Younger & Co., brewers, of Edinburgh, have, however, recently made some experiments in this direction, and under my guidance have fitted up a Bell-Coleman machine for cooling cellars, in which they brew and store lager beer. This kind of beer is fermented at a temperature of 40° or thereabouts, and the apartment in which the process is carried on measures 136 × 38 feet in area. The machine delivers about 30,000 cubic feet of air, cooled to 80° below zero, by wooden shoots to all parts of the room, so as to maintain an even temperature of about 40°, and has been exceedingly successful for the purpose.

* Abstract of a paper read before the Glasgow Section of the Society of Chemical Industry.

GOLD AND SILVER IN THE VAPOR OF PHOSPHORUS.

By P. Hautefeuille and A. Perrey.

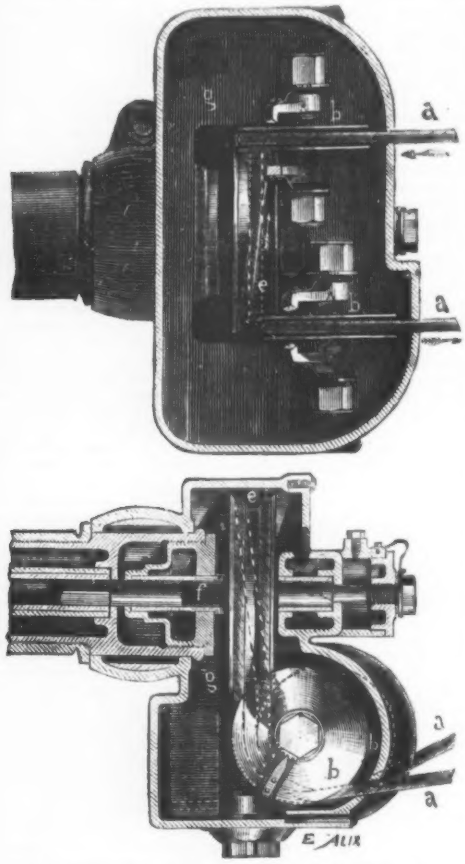
While endeavoring to reproduce the curious silver phosphides described by Pelletier in 1792, the authors have been led to study the action of the vapor of phosphorus upon silver and upon gold. In this action there are produced phenomena of the same order as those described by Dumas. Observations have also been made which show more precisely the influence of the change of the physical state of bodies upon the statics of chemical combinations. At the temperature at which it softens, silver rapidly absorbs oxygen; at a heat a little below its melting point it readily absorbs the vapor of phosphorus, at a tension below the atmospheric pressure. Phosphorus renders silver more fusible. At the heat equal to its softening point, and in a current of an inert gas, silver retains a large proportion of the oxygen absorbed; at the temperature at which the phosphorized silver remains melted it retains a large proportion of the phosphorus absorbed. On solidifying in the air silver abandons a portion of the oxygen taken up; on solidifying in the vapor of phosphorus it abandons the whole of the phosphorus. Gold absorbs the vapor of phosphorus at a temperature below its melting point, retains it at a higher temperature, and spits on cooling. Phosphureted gold loses its phosphorus at a temperature of 400° to 500°. Most other metals form permanent compounds with phosphorus.

ELECTRICITY APPLIED TO THE DRIVING OF GALLERIES IN MINES.

We have several times called attention to the application of electricity in mines, either for lighting or for the transportation of power and its utilization in the different operations that are performed in the galleries.

On the present occasion we shall speak of the electric rock drill devised by Mr. Taverdon.

This apparatus is the more interesting in that electricity subserves therein, not only for the transmission of power, but also for the manufacture of the drills. The mechanical apparatus that are employed for mining are divided into two kinds—those that operate through percussion, and those



Figs. 2 and 3.—PULLEY AND ROLLER BOX.

that revolve. Mr. Taverdon employs one of the latter kind, and has applied to it an electric transmission of power.

His system is based upon the use of tools which are provided with black diamonds at their extremity, designed for boring the hardest rock. Black diamonds had already been used in American machines, but their fixation at the extremity of the tool left much to be desired. This was effected by simply enchasing them, and the result was that the success of the operations depended upon the care with which the workmen who fixed the drills did their work; for diamonds which are badly set become loose, and after coming out of their cavity, at length become obstacles. It will be understood, moreover, that such accidents frequently occur, since any enchasing, of whatever nature it be, gives the diamond but a small number of bearing points, and leads to its loosening and even its breakage by getting out of true.

Fig. 1.—THE ELECTRIC MINING DRILL.

In order to hold the diamond at every part, Mr. Taverdon has recourse to a strong solder which penetrates the hollows; but, as this cannot be applied directly to the stone, he first covers the diamonds, through electrolysis, with a thin layer of copper. This coating permits of the application of the solder, and afterward disappears in those parts of the diamond that are to be used.

Mr. Taverdon first actuated his rock drill by means of a steam engine, compressed air, or water under pressure. Fig. 1 shows how he has arranged his apparatus for transmitting motion by electricity. The drill and electric motor are each placed upon a special car. The former is carried upon a vertical column whose extremities are thrust against the top and bottom of the gallery by a spiral spring, thus holding the car perfectly stationary. The drill is capable of moving around a vertical and a horizontal axis, so that it can assume any position desirable. It carries at one extremity the drilling tool, and at the other a motor which is so constructed that it can operate indifferently with steams, compressed air, or water under pressure.

In the electric arrangement this motor is replaced by a box which contains a pulley and rollers for guiding the cords that come from the electric motor.

This latter consists of an octagonal Gramme machine of the type employed in the Sermaize experiments. The pulley that terminates its axis receives a driving cord, the two ends of which, after passing over two other pulleys (one of which has a regulatable position), reaches the box at the end of the drilling machine. The details of this box are shown in Figs. 2 and 3. The cord is guided by the rollers, *b* and *b*, and runs round the pulley, *e*, which communicates motion to the tool. Through this arrangement, the machine may be turned in different directions without disarranging the transmission.

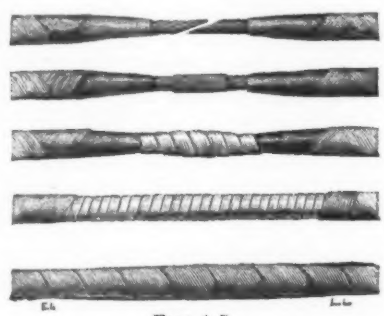
Upon the car that carries the motor there is likewise a reservoir of water that contains air in its upper part. The water enters this under a certain pressure, and is forced by the tension of the air into the machine, just as happens in fire engines, and afterward makes its exit through a waste pipe. The role of this water is to wash out the hole made by the tool, and remove the sand in measure as it forms.

The advantage that electric transmissions possess for operations of this is easy to understand. They prevent the incumbering of the gallery by steam piping or air or water piping, in which, moreover, there are frequent leakages that occasion stoppages in the work.

Mr. Taverdon asserts that in all the trials that he has made of his electric rock drill he has obtained results equal to those that are given by the best steam drills and superior to those given by compressed air.—*La Lumiere Electrique.*

ON MAKING JOINTS IN WIRES USED FOR ELECTRIC LIGHTING.

The India Rubber and Gutta Percha Co., of Silvertown, London, has given the following directions for making



Figs. 1-5.

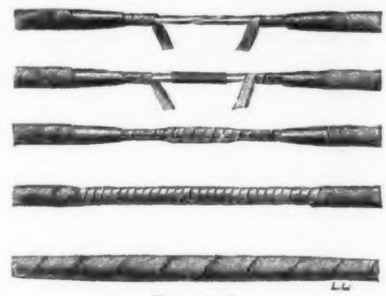
joints in conductors for the arc and electric lights. The annexed figures are reproduced from the Electrician's Pocket-book of Messrs. Munro & Jamieson.

In preparing the ends of the principal conductors, remove the two external tapes for a length of about five inches from each end to be joined. Remove the rubber and the internal layer of tape for about one and one-half inches and lay the wire bare with emery-paper (Fig. 1). Solder together the wires that compose the cable, for a length of about an inch, and bevel off the two extremities with a fine file. Bring the two beveled ends together, and solder them in such a way as to obtain a conductor of uniform thickness. Wind a fine copper wire spirally around the joint, and solder the whole together as shown in Fig. 2, and always use resin instead of acid as a flux.

Afterward, to apply the insulating material, take a very sharp knife and work the rubber to a point for a length of half an inch from the conductor, and cover the metallic joint with a layer of prepared cotton tape, five-eighths of an inch wide (Fig. 3). Over the tape wind spirally a band of pure rubber, three-fourths of an inch in width (stretching it well in doing so), and cover the joint with a series of wrappings running alternately to the right and left, until it gets to be as thick as the rubber covering of the wire, or a little thicker. This stage is shown in Fig. 4. After this, it is necessary to apply a small quantity of a solution of rubber to each layer, and allow the alcohol sufficient time to evaporate before putting on another layer.

This effects a union of the different layers of rubber. The external covering of the conductor is composed of two layers of prepared tape, five-eighths of an inch in width, applied in opposite directions, with a strong gum lac varnish between them; and above these, again, a layer of impermeable tape, with a coat of varnish over all (Fig. 5). Care must be taken to keep the bands, tools, and materials clean and dry.

These instructions apply to the principal conductors. In branch lines for incandescent lighting, the extremities are prepared by removing the braid, tape, and rubber for a length of about four inches at each end, and unwinding the cotton



Figs. 6-10.

covering of the conductor for about an inch and a half. The extremities of the wire are then cleaned with emery-paper and beveled off with a fine file, as shown in Fig. 6. The two beveled edges are then brought together and soldered, while a thin copper wire is wound around as before (Fig. 7). The metallic joint is then covered with the thin layer of cotton that has previously been unwound from the extremities (Fig. 8).

Over this cotton covering there is wound spirally, and in a contrary direction, a ribbon of pure rubber, five-eighths of an inch wide (care being taken to stretch it as before) until an insulation of the desired thickness is obtained (Fig. 9). In this case also a solution of rubber is applied to each layer in order to make the whole solid.

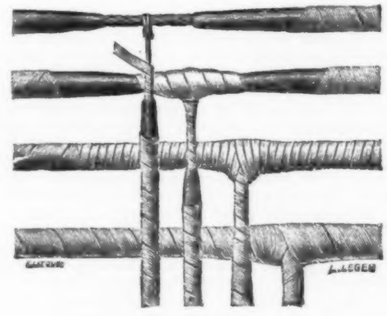
Finally, two layers of felt tape, five-eighths of an inch wide, are applied in an opposite direction, with an intermediate layer of strong gum lac, and, over all, a coat of varnish (Fig. 10).

In T-shaped joints of branch wires for incandescent lighting the ends are prepared by removing from the principal conductor five inches of the two external layers of tape. After this the rubber covering and internal tape are removed from the wire for a length of an inch and a half. Six inches of the external covering and tape are removed from the end of the wire that is to be joined to the principal conductor. The two layers of rubber and the cotton are afterward drawn back for three inches, and the rubber is removed—the cotton being left for covering the metallic joint. The wires that compose the conductor should be soldered together, and the solid wire wound two or three times around the principal conductor and afterward three or four times upon itself.

Then the whole is soldered together (Fig. 11). Each end of the principal conductor must be worked to a point with a very sharp knife, for an inch and a half, and the solid wire be covered with cotton up to its junction with the principal conductor and all around. The metallic joint must be covered with a wrapping of cotton tape covered with rubber (Fig. 12).

A well stretched band of pure rubber, five-eighths of an inch wide, is applied spirally, the winding being begun at the rubber covering of the solid wire, running to and around the joint, and as far as the rubber covering at each end of the principal conductor—thus forming a series of layers in opposite directions, until the desired thickness is reached (Fig. 13).

As in the preceding cases, it is also necessary here to apply the solution of rubber between the layers. Externally, the wire is protected by two layers of prepared tape (five-



Figs. 11-14.

eighths of an inch wide), wound around in an opposite direction, with an intermediate coating of a concentrated varnish of gum lac, then above this an envelope of impermeable tape, and finally a coat of varnish (Fig. 14). All these operations must be performed with the greatest neatness and with dry bands.—*La Lumiere Electrique.*

ANDERS' TELEPHONE TRANSMITTERS.

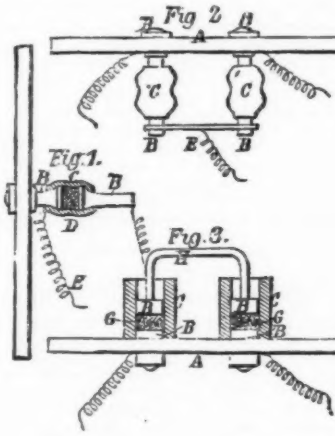
The telephone transmitters by Mr. G. L. Anders, of Queen Victoria street, E. C., are of the contact pressure type, and are chiefly noticeable for their simplicity and the use of osmium in fine grains—doubtless a very suitable material, but rather expensive. According to Mr. Anders, who does not explain how he prepares the granulated metal, the properties which render osmium especially suitable for the purpose are great hardness, infusibility, and sensitiveness to microphonic action. In some instances he employs aluminum for one surface and osmium for the other, because of its high conductivity for heat and electricity, which properties reduce its liability to fusion at the points of contact. Both of the above named materials, moreover, are free from the defect of producing a non-conducting or easily fusible coat-

ing by exposure to the air, or under the action of the current.

Fig. 1 is a side view, partly in transverse section, of part of a transmitter.

Fig. 2 is also a side view of another form, while Fig. 3 illustrates a modification. A is the diaphragm, which may be made of any suitable material. B B are the electrodes, preferably formed of any metal not easily oxidized or fused. One very advantageous manner of carrying the invention into practice consists in placing granulated osmium between two disks or pieces forming the electrodes and inclosed in a tube or sleeve of India rubber, cork, or other suitable material, as in the instrument shown in Fig. 1. In this instrument one of the electrodes, B, is attached to the center of the diaphragm or soundboard by a screw and nut or by other suitable means; the electrodes are formed with disks or other pieces inclosed in and kept at the required distance apart by the tube or sleeve, C. The space, D, between the disks or buttons is filled or nearly filled with grains of osmium. The conducting wires, E, are connected with the electrodes, B, as shown. The instrument shown in Fig. 2 has the above specified parts in duplicate, the outer ends of the electrodes, B, being connected by a small bar or plate, E'.

Sometimes the patentee employs a small quantity of granulated osmium intimately mixed with aluminum leaf or foil by rubbing them together. In this instrument other metals can be used in place of aluminum to form the electrodes, B, as the principal part of the microphonic action takes place between the mixed grains of osmium and aluminum. In this modification, in which one electrode is attached to a diaphragm or sounding board, the other electrode may be pressed toward it by its own weight. If desired, the two electrodes may be set firmly in the ends of a glass or other tube with sealing-wax or other cement, and the whole mounted upon a diaphragm or sounding board. According to another modification, one electrode is attached to the diaphragm of the transmitter, and about its free end a collar or tube of cork or similar material is fitted, into the end of which the other electrode enters. A space is left between the two electrodes, in which is placed a short cylinder or disk of aluminum, the surfaces of which are prepared by impressing grains or particles of osmium into them. The electrodes should be faced with platinum or other inoxidizable metal. The collar or tube must fit tightly enough on the electrode on the diaphragm to enable the electrode to support the other parts. An adjusting screw fitted into the back of the case serves to vary the pressure upon the electrodes. This form of my instrument is shown in Fig. 3. G G are pieces of



aluminum which have the grains of osmium pressed into them and which are inclosed in the tubes, C, and between the electrodes, B. The two outer or upper electrodes are connected by the wire or rod, H. As the aluminum is sufficiently soft to permit particles of osmium to be readily united thereto by pressure, the patentee sometimes uses the osmium at the tip or point of an electrode formed of aluminum, and forms both electrodes of aluminum. Although Mr. Anders' experiments indicate that the best results are obtained by the use of aluminum in the manner described, yet other metals possessing to a greater or less degree the qualities which render aluminum serviceable may be employed in combination with osmium.

EXPERIMENTS ON THE PASSAGE OF ELECTRICITY THROUGH GASES.—SKETCH OF A THEORY.*

By Arthur Schuster.

The passage of electricity through gases has of late years become a very favorite subject for experimental investigation. A large number of facts have thus been accumulated, and it becomes of importance to see whether these facts throw any light on the theoretical notions which we have based on other branches of electrical inquiry.

If we have two bodies at a different electrical potential separated by a layer of air, we might imagine the air in contact with the bodies to become electrified, then move on, impelled by the electric forces, and re-establish equilibrium by giving up their charges. The passage of electricity through gases would then be similar to the diffusion of heat. But, however natural such a view would be, it is impossible to maintain it in the face of experimental facts. The experiments which I shall bring before you to-day seem to me to support, on the contrary, the idea that the passage of electricity through a gas resembles the phenomenon studied by Helmholtz under the name of electrolytic convection.

I shall avoid as much as possible all suppositions and hypotheses which cannot be put to the test of experiment; but it seems necessary to start with some assumption in order to avoid too great a vagueness in the subsequent explanations. The assumption which I shall make is this: In a gas the passage of electricity from one molecule to another is always accompanied by an interchange of the atoms composing the molecule. I shall also try to prove that many facts are easily explained by the assumption that the molecules are broken up at the negative pole.

If, in a vacuum-tube of the ordinary form, the discharge is passed at a pressure of about one millimeter, a luminosity is seen round the negative pole which is called the negative glow. A luminous tongue projects from the end of the positive pole, which I shall call the positive part of the discharge without meaning to imply that it is charged with positive electricity. The positive part of the discharge and the negative glow are separated by a non-luminous space, which I shall call "the dark interval." The glow itself is divided into three layers, the thickness of which increases with decreasing density. Closely surrounding the electrode itself, we have in the first place a luminous layer, which on new electrodes is of a golden color. The spectroscope shows the presence of sodium and hydrogen; the sodium is due to foreign matter deposited on the electrode, and the hydrogen is expelled by the action of the heat out of the electrode by which it had been absorbed. When the electrodes have been in use for some time, the golden color disappears, and the spectrum belonging to the gas used is seen. The second layer is known by the name of the dark space. The third layer is the glow proper.

The theory which I shall endeavor to establish is this: That within the first layer the gaseous molecules are decomposed, that their negative parts are projected with great velocity through the dark space, that this velocity is gradually reduced by impacts within the glow, and that in the positive part of discharge the discharge takes place by diffusion except when stratifications appear.

According to the kinetic theory of gases, the molecule of mercury vapor consists of a single atom, which is incapable of vibration. Mercury has a very brilliant spectrum, which proves that the theory is incomplete in some important point. It is well known, on the other hand, that the theoretical conclusion receives support from the fact that the vapor density of mercury vapor is anomalous. If, as is generally supposed, the molecule of the majority of gases contains two atoms, that of mercury can only contain one. If an essential part of the glow discharge is due to the breaking up of the molecules, we might expect mercury vapor to present other and much simpler, phenomena than the gases with which we are generally accustomed to work. *This, indeed, is the case; for I find that, if the mercury vapor is sufficiently free from air, the discharge through it shows no negative glow, no dark spaces, and no stratifications.* At the ordinary temperature the spark does not pass through mercury vapor; but if a tube free of air, but containing mercury vapor, is heated, the discharge passes always in a continuous stream of light. It is not always quite symmetrical with respect to the two poles; and a very curious tendency of the spark is noticed, to pass at the negative pole rather from the glass out of which the electrode protrudes than from the metallic electrode itself. A brilliant sodium spectrum then appears at the point from which the spark sets out. Whenever small traces of air remain, stratifications are very apt to appear, as a mixture of air and mercury gives fine stratifications, but I have never noticed them after sufficient removal of the air.

I now pass to the description of an experiment which seems to me to be only capable of explanation by the views brought forward in this paper, and I should like therefore to consider them as crucial experiments which have to be explained by any true theory of the discharge. As negative electrode, I use an aluminum cylinder of 5·5 cm. internal diameter and 8 cm. long. A long aluminum wire running parallel to the axis of the cylinder at a distance of about an inch formed the positive electrode. On exhaustion, the discharge at first passes as a spark in the ordinary way, but as the pressure decreases the glow gradually surrounds the whole cylinder, *with the exception of a dark strip about 2 or 3 cm. in width, directly opposite the positive wire.* The positive electrode seems, therefore, to repel the negative glow.

The following seems to me a plausible explanation of the phenomenon which I have just described. The rapid fall of potential which is observed on crossing the negative electrode suggests at once, independently of any theory that we have to deal with, the action of a condenser, for we know that no statical charge can produce a finite difference of potential at the electrode, while a double layer will produce a discontinuity. Although it may not be proved that an absolute discontinuity of potential exists at the cathode, it is yet certain that a very rapid fall occurs at that place. This is all that is necessary for the argument.

We recognize such a double layer in the case of electrolytes, but there is an essential difference in the thickness of the layer within which we must imagine that condenser action to take place. In the liquids that thickness must be very small, as is showed by the intensity of the observed polarization currents. The positively electrified matter in every case is kept against the negative surface by a joint action of electrical and chemical forces, for it has been shown by Helmholtz that only thus can we explain a difference of potential between two bodies. It is the chemical forces which keep the electricities asunder. The gaseous molecules or atoms, however, subject to their mutual encounters, and always having certain velocities, will tend to leave the surface. They are kept near the surface, however, by the electrical forces.

Suppose, now, that a positive electrode is placed near such a condenser. The resistance of the gas is so much greater than that of the metal electrode that we shall assume the whole electrode to be of the same potential. The lines of force will then cut the surface at right angles, and could we assume the condenser to be infinitely thin, there would only be a normal force acting on its particles; but as the lines of force are curved, the particles not in immediate contact with the surface are acted on by a tangential force which will tend to drive them away from the positive electrode. As a steady state will only be possible when the total force is normal throughout the condenser, we arrive at the condition for the steady state that within the condenser the fall of potential must be the same for equal distances measured along the normal to the surface.

Experimental evidence speaks strongly in favor of such a conclusion. If, for instance, a thin wire is used as electrode, it is well known that the tension at the end of the wire before discharge is very much larger than anywhere else. At high pressures the discharge passes indeed from the end of the wire, but as the exhaustion proceeds, the glow gradually covers the whole wire, and the same amount of electricity flows out of equal areas situated anywhere on the wire, for the dark space which alters its width with the intensity of current is everywhere the same; this implies that the fall of potential per unit distance is the same all over the wire.

Hitherto we have only assumed a certain number of particles positively electrified in the immediate neighborhood of the negative electrode, and we have left it altogether undecided what these particles are. But if we consider now the fact that the glow does not appear opposite the positive electrode, that is to say, that while the fall of potential is the same all over the surface the flow is stronger at some places than at others, we are driven to the conclusion that the flow does not altogether depend on the fall of potential, and we must again look for an explanation in the chemical as well as the electric forces. Wherever the fall of potential is chiefly produced by the presence of the positively electrified particles, which I now assume to be the decomposed molecules of the gas, these will help by their chemical action to decompose other molecules. Opposite the positive pole the fall of potential is principally due to nearness of that electrode; chemical forces are absent, and the molecules will not be decomposed. This is, I believe, the explanation of the dark area. And it brings with it the explanation of a large quantity of other facts, as, for instance, the one which has been so long observed and well established, that once a current is set up in the gas it requires a much smaller electromotive force to keep it going. For the discharge, according to us, will generally be introduced by a spark which must give the first supply of decomposed molecules before the continuous glow discharge can establish itself.

I may for the sake of clearness once more mention shortly the principal points of the argument.

The rapid fall of potential in the neighborhood of the negative electrode renders the presence of positively electrified particles in its neighborhood necessary.

If the distance through which the condenser action takes place is sensible, the positively electrified particles will be acted upon by a neighboring positive electrode.

A steady state will be established in which the fall of potential along the normal from the surface will be everywhere the same.

As however the flow is stronger away from the positive electrode, we must conclude that other forces besides electrical forces determine the flow.

It is natural to assume that these are chemical forces; that, in other words, the positively electrified particles are the decomposed molecules, which by their presence assist the decomposition of others, and therefore the formation of the current.

Unless a flaw is detected in this line of argument, I think that the conclusion must be granted, namely, that the decomposition of the molecules at the negative electrode is essential to the formation of the glow discharge. This is really all that I endeavor to support in this paper. The rest can only be settled by further experiments. And among the rest I count also the primary cause which originally produces the decomposition of molecules at one pole rather than at another. It is possibly due to an electromotive force of contact between the gas and the electrodes, which tends to make the gas electro-negative.

The gaseous molecules, then, according to our theory, are decomposed at the negative pole. Their negative constituents can follow the electric action, and as the fall of potential in the immediate neighborhood of the pole is very rapid, the atoms will leave the pole with considerable velocity That the region of the dark space is filled with matter projected from the negative pole follows almost conclusively from the experiments of Goldstein and Crookes, and is also shown in a most striking way by an experiment due to Hittorf. If a tube contains two parallel wire electrodes at a distance of say a quarter of an inch, the discharge will at high pressure pass in the usual way from electrode to electrode, but at very low pressures the discharge from the positive pole goes away from the negative. The results can be shortly expressed by saying that, as far as the positive is concerned, the inner boundary of the dark space forms the negative electrode. If the dark space is small and does not reach to the positive pole, the discharge passes from the latter toward the negative pole, but as soon as the dark space extends beyond the positive pole, the positive part of the discharge goes toward the nearest point of the dark space, that is, straight away from the negative pole.

We have then two closely adjoining, almost overlapping, parts, in which the discharge is in opposite directions, and this could not be unless electricity is carried by matter which can, owing to its inertia and high velocity, move against the electric forces. To my mind this experiment proves conclusively that the negative electricity is bound to matter projected with high velocity away from the negative pole.

Goldstein has shown that when a thin pencil of the negative glow belonging to one electrode passes close to another, the pencil is deflected. According to our view, such a pencil would be formed by a succession of negatively charged particles projected in nearly the same direction away from the negative electrode; as these particles pass by another cathode, they are naturally deflected out of their path by the electric forces. Goldstein has shown that if the current is equally divided between the two cathodes, the deflection is independent of the intensity of the current, the pressure, and the nature of the gas. This is exactly what ought to happen according to our theory, for strengthening the current at one cathode means, as will presently appear, increasing the velocity of the particles. The square of the velocity will increase in the same ratio as the total fall of potential in the neighborhood of the negative pole; as the particles pass the other cathode, the forces from it are increased in the same ratio as the square of the velocity with which they are moving, and consequently the path will remain the same. Similarly all the other experimental facts established by Goldstein can be easily explained.

The most conclusive proof of the view adopted in this paper would be found in the demonstration that the amount of electricity carried by each particle was always the same, whatever the current. I propose to test this fact in the following way: It was found by Hittorf that the particles proceeding from the negative electrode, and projected at right angles to the lines of force in a magnetic field, are bent round in a circle. This is as it should be, and I calculate that the radius of the circle ought to vary as $\sqrt{F/e}$, where F is the total fall of potential within the region in which the particles acquire their velocity, and e is the amount of electricity carried by each particle. As the current increases, it is shown by Hittorf that F increases; and I find that at the same time the diameter of the ring in the magnetic field increases. If this diameter varies as the square root of F it would be proved that e must be constant, as it is in electrolysis. At present we can only say that the average amount of electricity carried by the particles must increase less rapidly than the fall of potential. If e varies at all, we should expect it to vary proportionally to the fall of potential in the neighborhood of the negative electrode, and in that case the diameter of the ring would be independent of the current, which it is not.

The theory which I advocate involves the existence of a polarization, and it might be considered a difficulty that no polarization currents have with certainty been observed in gases. I believe the difficulty only to be apparent, for the experiments prove that the fall of potential near the negative pole, though rapid, is not sudden, so that the layer within which the condenser action takes place is very much thicker in gases than in liquids. The capacity of the condenser is therefore smaller, and though the total fall of potential in

* Abstract of the Bakerian Lecture. Read before the Royal Society, June 19, 1884, by Arthur Schuster, Ph.D., F.R.S.—*Nature.*

the gas may even be stronger than in the liquid, the polarization currents might escape observation.

With regard to the positive part of the discharge it will be sufficient here to mention that stratifications are principally observed in mixtures of gases or in compound gases, and that in the intervals between two stratifications the discharge is very likely carried as through the dark space at the negative electrode, while in the stratifications recombination of the decomposed atoms takes place.

An interesting law has been proved by Hittorf and E. Wiedemann in the case of the unstratified discharge. Hittorf shows that the fall of potential is the same in the positive part for the same tube whatever the current. This means that the energy dissipated is proportional to the current, and not to the square of the current, as in a liquid. In the latter form the proposition had previously been proved by E. Wiedemann, who has shown that the total quantity of heat generated is proportional to the total quantity of electricity which has passed through the tube, whether in a few strong sparks or many weaker ones.

These experiments seem to point to the fact that once the original velocity of the particles at the regular pole has been reduced, the velocity becomes independent of the strength of the current, that is to say, that in the positive part of the current greater intensity only means a greater number of particles taking place in the discharge.

The paper also contains spectroscopic evidence as to the state of dissociation in a vacuum tube, especially in the negative glow.

The question as to how the electricity passes from the electrode to the gas is not discussed, nor is it possible at present to decide, should the theory prove true, whether the polarity of the atoms in the molecule depends on the way in which these are combined, or whether that atom takes positive polarity which happens to be nearest the negative electrode as the molecule approaches it.

In conclusion some novel influence of the magnet on the negative glow is described, and it is shown that two different effects have to be clearly distinguished. The first in an effect of the magnet on the discharge when that discharge is established, and has been sufficiently well investigated. But the second effect depends on the question from what part of the negative electrode the discharge sets out. With respect to this question we meet with many contradictory and inaccurate statements. If at any place the magnet tends to throw the glow together the temperature will be raised, and owing to this fact the current will be strengthened, which again raises the temperature. It may thus happen that a slight cause can induce the current to pass almost exclusively from one part of the negative electrode. For a detailed description the reader is referred to the paper itself and the illustrations accompanying it.

THE ELECTRIC CONDUCTIVITY OF METALS AND THEIR ALLOYS.

MR. LAZARE WEILLER, who has been making some extended researches at the Breguet and Angouleme works regarding the behavior of different metals and their alloys when used for transmitting electricity, has recently presented a resumé of his results to the International Society of Electricians.

The experiments were made with bars of metal which were cast especially for the purpose, which had a diameter of about thirteen millimeters and which were cut so as to render the grain of the fracture apparent, and then drawn out into a wire if the metal permitted it. In the following table of conductivities drawn up by Mr. Weiller, pure copper and pure silver are taken as standards of comparison.

Pure silver	100
Pure copper	100
Telegraphic silica bronze	98
Alloy of copper and silver, 50%	86·65
Pure gold	78
Pure aluminum	54·2
Telephonic silica-bronze	35
Pure zinc	29·9
Telegraphic phosphor-bronze	29
Alloy of gold and silver, 50%	16·12
Swedish iron	16
Pure Banca tin	15·45
Aluminum bronze, 10%	12·6
Siemens steel	12
Pure platinum	10·6
Pure lead	8·88
Pure nickel	7·89
Antimony	3·88

These conductivities are established from a comparison with that of a wire of pure silver 1 mm. in diameter, which at 0° C. possesses a resistance of 19·37 ohms per kilometer. It follows from these figures that chemically pure silver and copper are the best conductors of electricity. Of course, the use of silver for conducting lines and electric apparatus is out of the question, but the same is not the case with copper, the price of which is sufficiently low to allow it to be employed in industrial applications. The purity of copper has considerable influence upon its conductivity, as may be seen from the following data given by Mr. Preece, in regard to the variations of such conductivity following the improvements that have been introduced into the manufacture of the metal:

Cables	Years.	Conductivity.
Dover-Calais	1851	42 per cent.
Port Patrick and Donaghadee.	1852	46 "
Transatlantic	1856	50 "
Red Sea	1857	75 "
Malta and Alexandria	1861	87 "
Persian Gulf	1863	89 "
Transatlantic	1865	96 "
Irish Sea	1883	97·9 "
Pure copper		100 "

—*Chronique Industrielle.*

THE STANDARD OF LIGHT ADOPTED BY THE PARIS CONFERENCE.

THE International Conference lately held at Paris adopted as a standard of light the amount emitted by one square centimeter of melting platinum at the point of solidification. Werner Siemens points out that the practical determination of this unit is beset with difficulties, since platinum at the melting point readily takes up foreign substances which change this melting point. He therefore recommends the use of the following apparatus, which, however, determines the light given out by the platinum at the point of melting and not at the point of solidification. With pure platinum, however, the difference is very small. The method is based upon the melting of a very thin plate of platinum by a current of electricity.

The platinum is inclosed in a metallic case provided with a hole 0·1 square centimeter in section, which is immediately over the melted platinum. The sides of this hole are conical, and the platinum foil extends beyond the hole in every direction. At the instant of the melting of the foil a quantity of light equal to 0·1 of the standard is emitted from the hole.

By suitable modification of the strength of the electrical current the melting of the platinum can be delayed until the proper moment of comparison with another light has arrived. Preliminary measurements with this apparatus show that the light emitted from the hole at the point of melting of the platinum is about 1·5 times the English standard candle.—*Ann. der Physik und Chemie*, 1884.

A MODIFICATION OF HUGHES' MAGNETIC BALANCE.

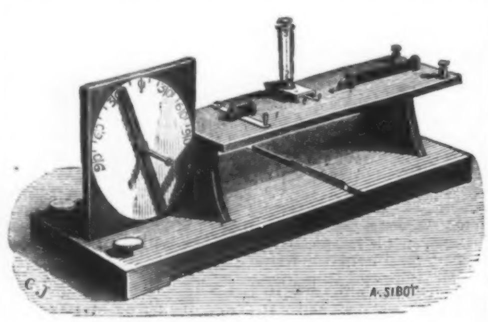
THE annexed figure represents Hughes' magnetic balance modified according to the following suggestions of Prof. S. P. Thompson:

1. The compensator should be fixed in such a way as to revolve against a vertical circle placed at right angles with the magnetic meridian, with its center on a level with the indicating needle, and magnetically to the east or west of the latter. In this position the magnetic force of the compensator has no resultant in the magnetic meridian at the point where the needle is placed. Consequently the sensitiveness of the latter is the same in all the positions that it may occupy in its own plane.

2. A small magnet, placed magnetically north and south of the indicating needle, is employed for rendering the latter astatic to the degree desired.

3. The compensator is so placed that the distance between its center and that of the needle is about 4·6 times half of the space between its poles. If the compensator is not a very thick, flat, and straight magnet, we may suppose, approximately, that the distance of the poles from the ends is one-tenth of the total length, so that a selection of a distance equal to five times half the space between the ends of the magnet cannot give rise to much error. This granted, we may safely suppose that in all positions of the compensator within 55° of each side of zero the magnetic force that it will exert upon the pole of the needle will be about 2 per cent., proportional to the degrees of the scale that the compensator has traversed, and proportional to 1 per cent. for angles under 45°. There will be no need, then, of a special table of graduations for all those practical cases in view of which the magnetic balance was invented.

4. As it is impossible to obtain a vast field of compensation for large and small magnetic forces by diminishing or



MODIFICATION OF HUGHES' MAGNETIC BALANCE.

increasing the distance between the compensator and the needle, I propose to attain such a result by placing over the compensator a second magnet that is capable of revolving around the same axis and that has the same length. In an analogous way, a third magnet may be added for increasing the magnetic momentum of the compensator.

5. As the use of a very small needle is accompanied with less sensitiveness in the indications, I propose to substitute a needle of the type called unipolar, that is to say, having one pole fixed in the axis of revolution, so that a single pole is caused to revolve around the suspension axis. A steel needle, 5 cm. in length, is bent at right angles at 1·5 cm. from its extremity, and the silk suspension thread is attached to the bent end. A counterpoise is added behind, and another small weight is placed beneath upon a brass wire attached immediately under the center of suspension. The sole effective pole of this needle is in the axial line of the balance, at the same level as the center of the compensator.—*La Lumière Electrique.*

THE DAKOTA TIN DEPOSIT.

IF the reports of the recent discoveries of tin at the Black Hills, in Dakota, are of a reliable character, as they certainly appear to be, the United States is destined to become the leading tin producer of the world.

The world's production of this metal last year amounted to 45,770 tons, about one-third of which was consumed in the United States. The countries which produce tin are those bordering on the straits of Malacca, in the East Indies, Australia and the Cornwall district in England. All the tin consumed in this country has been imported almost wholly from England and English colonies, but the recent discovery in the Black Hills will, if the statements made are correct, revolutionize the trade. According to Professor Bailey, the deposits there are so vast as to be able to supply the whole world for centuries.

The center of the district, which covers an area of twelve miles by seven or eight, is Harney Peak. The tin-bearing rock can be quarried from the surface instead of being followed underground, and he claims to have seen veins of it of more than fifty feet in width which will average much better than the Cornish veins, where the ore has to be raised from a great depth at a heavy cost. Of the stream tin which can be obtained by sluicing, and which will yield about fifty per cent. of pure tin, he speaks as follows:

"The stream tin alone is so abundant that all the companies that could possibly work it could go on for 20 years without exhausting it. Yet this is but the waste, you might say, of the main deposit—the mere scraps that water and frost have detached, a little bit at a time from the great mass and source of the ore, which is Harney Peak, itself more than a mile high, and the surrounding tin-bearing rock, which, as I have already said, extends for miles. It is impossible to imagine this great body of ore ever being exhausted. As to profit, the richness of the ore compared with that of any other tin-bearing district of the world settles that conclusively."

THE FIRST DISCOVERY

Of this deposit was made in the Etta mine, in Harney range, about the first of June, 1883, since which time discovery has been made at several localities of tin stone, the most important being that of Nigger Hill. Mr. Chapman, one of the owners of this mine, furnishes the following facts to a correspondent of the *Mining Review*:

The mineral was first noticed by Mr. Box, who, upon being shown a piece of heavy black rock taken from the gravel of the creek, announced the fact that it was tin. Search was at once instituted for the ledge which had afforded such an abundance of the ore in the shape of stream tin, and which had been the bane of the miners ever since placer mining had been inaugurated in the gulch, its high specific gravity rendering it almost impossible to save fine gold in sluicing or washing without amalgamation.

The stream tin is found usually as sand or small pebbles, though larger pieces have been found. One piece exhibited by Mr. Chapman weighs seventy-two ounces. The search for the ledge resulted in the discovery of a large vein, averaging over 100 feet in width, which has been traced for a distance of four miles. The inclosing rock of all the ore I have seen is orthoclase, the cassiterite being scattered irregularly through the mass in minute grains and crystals of considerable size. The country rock, through which the vein passes, from the description of Mr. Chapman I should judge to be a syenitic gneiss.

A large number of claims have been located on the vein, prominent among which are the Michigan, Lily, Rough and Ready, and Giant. A curious fact has been demonstrated on one portion of the lead: the tin-bearing rock comes to an abrupt termination and its place is taken by gold-bearing quartz, which continues for about 500 feet, when the tin ore as suddenly makes its reappearance, and, as far as is known, continues uninterruptedly. A shaft has been sunk to a depth of thirty feet on the gold-bearing portion of the ledge, which prospects well. A tunnel which was run to tap the vein on the Giant, after being driven a distance of 250 feet and cutting several seams of ore—all of which, I believe, carry tin—encountered a vein, into which the tunnel has been extended 100 feet, the face still being in ore carrying tin.

The miners have made rude tests of their rock by pulverizing and concentrating by washing; the concentrated ore then being smelted in a blacksmith's forge, the results invariably being good. In one instance, 40 pounds of rock was reduced to 10 pounds, and a bar of metallic tin, weighing one pound, smelted from it. The process, being rude, was necessarily very imperfect; as cassiterite carries about 78 per cent. of tin, the result should certainly have been more than 25 per cent. The main chain of mountains, constituting the axis of the uplift of the Black Hills, has a general trend northwesterly and southeasterly, and as the tin mines of Nigger Hill are located near the northern extremity of these mountains, and the mines of Harney near the southern end, it is reasonable to expect that other tin veins will be discovered along this range; indeed, tin has been discovered several miles north of Harney. Considerable development may be looked for in these mines during the coming summer.

[THE MICROSCOPE.]

A PECULIAR DUST IN SNOW.

IN February, 1884, a peculiar sediment was accidentally discovered in snow water at St. Joseph, Mo. Dr. H. Christopher needing some pure water for chemical purposes, melted some apparently clean snow, and called my attention to the above-mentioned deposit. Afterward a fine, feathery snow fell upon a coating of sleet and ice, which covered the surrounding country for hundreds of miles. Upon melting this surface snow, the water was found to contain the same unusual sediment. As the entire adjacent country, and the sand bars of the Missouri River, were covered with ice, it seemed remarkable to find this substance in snow falling upon it. Accordingly this dust was treated with chlorohydric acid, and heated on platinum foil at a red heat to eliminate any carbon or accidental organic matter. Upon washing it in a test tube, it was found to be so minute that portions of it required hours to settle to the bottom. Thinking it might possibly be of local origin, samples were gathered from different parts of the city, and from the country far from habitations. Some were treated as above, and some simply dried.

Its behavior under chemical examination convinced us of its silicious nature. It was then submitted to microscopical examination, and found to consist of flat plates and sharp angled fragments, transparent vitreous pieces, some brownish semi-transparent particles, jet black sharp-pointed pieces, and needle-like spicules. However, every piece, fragment or minute needle, showed a clean-cut, sharply defined margin, and no rounded masses with worn sides were found. After a careful examination it was considered volcanic dust. It was compared with sand from Coney Island, Lake Erie, the Mammoth Cave, and the Missouri River. These various sands were much coarser, appearing as rounded masses, destitute of the clean-cut edges of the snow sand. So great was the difference no one could confound the two. In order to guard against self-deception, thinking it might be ashes from anthracite fires, or dust from foundries and blast furnaces, they were obtained, and found to present an altogether different appearance.

Some of the snow sediment was given to different observers, with no hint as to its character or origin. They called it volcanic dust. Thus we were gradually forced to the belief in the volcanic origin of the specimens.

In order to pursue the matter further, samples were secured on the Atlantic coast from snow falling with the wind from the East, which would presumably give snow free from dust and sediment, having drifted in from air over the ocean. Sediment was also received from Utah snow. All these presented an appearance identical with that obtained in Missouri. A little later it was compared with volcanic matter from Vesuvius, and a striking similarity was at once apparent. The question naturally arises, Whence came this strange visitor? Is it cosmic or meteoric dust which the earth in its orbit has encountered? In former years observers have collected, in uninhabited countries, quantities of dust which was considered meteoric, and is described as "little rounded particles of metallic compounds, unlike anything the earth is known to produce, and strikingly like what meteors of that size would be." That is decidedly unlike the snow sediment.

For another reason this snow sand could scarce be cosmic dust ejected from some planet, as such action could not be vigorous enough to throw such minute particles beyond the

attraction of the place of their origin; particles so small, no matter how forcibly ejected, could not escape the attraction of gravity forcing them back to their home.

It will be remembered that on August 26, 1883, one of the most tremendous convulsions known to history wrought immense havoc in Java. Large tracts of country were wrecked, and from Krakatoa tons upon tons of volcanic dust, to say nothing of more bulky material, were ejected with inconceivable force, which coupled with the mighty up-draught of the eruption must have carried the fine particles almost to the confines of our atmosphere. Having once attained a great altitude, borne by the ever-present air-currents, they would drift for months, and in a comparatively short time encircle the earth, and if they were of the same electrical sign as the earth, for instance, both electro negative, the repellent action of this subtle agent would prevent their rapid precipitation. Experiments have proved this, and heretofore volcanic dust has been known to remain aloft a long time. Shortly after this eruption at the Straits of Sunda, colored suns and strange glowing sunsets startled the inhabitants of comparative neighboring countries by their wierd appearance. These sunsets gradually spread over the earth, and were noticed in this country first in the latter part of November, and during the winter were at their height.

These reflections could not have been caused by the vapor of water, for reasons we will not stop to discuss, but must have come from finely divided solid matter.

The gradual expansion of this phenomenon over the earth after the catastrophe at Java, and the finding of this peculiar deposit in snow from the Atlantic coast, in Missouri, and in Utah, at a time when the glowing sunsets were bright, force us to the conclusion that after its long flight from Krakatoa we have imprisoned the cause of this great light under our cover glass beneath our objective.

In confirmation of this, notice the following facts: April 19 and 20 were days of almost continuous rain at St. Joseph, by which the air should have been washed clean of all local or surface dust. On the following day snow fell quite abundantly for a few hours; this was secured in clean vessels and melted. This contained a very limited amount of particles so small as to be quite difficult to handle, but the microscope showed them to be of the same character as their predecessors of the winter. At this time the brilliant sunset had faded to a faint blush that lingered after the ordinary tints of the setting sun had disappeared. Thus the sunsets and the attendant dust were disappearing *pari passu*, and thereby strengthened our faith in what at first seems a preposterous proposition, viz.: the snow sediment is volcanic dust from Krakatoa and the cause of the glowing sunsets.

Since writing the above, some dust from Krakatoa that fell on the deck of the ship Wm. De Grasse on the day following the eruption has been received from Mr. Wharton, of Philadelphia. Although considerably coarser, its appearance is so strikingly similar to that gathered at St. Joseph, we are forced to believe them both to have the same origin.

H. W. Westover, M.D.

St. Joseph, Mo.

THE EARTHQUAKE RECORDER.

During the past session of the Philosophical Society of Glasgow, a paper was read giving a description of an apparatus which had been designed for the purpose of recording the time of occurrence, the duration, and the nature and magnitude of the motions in an earthquake. In the light of recent events this paper has a special interest. The author was Mr. Thomas Gray, B.Sc., F.R.S.E., recently a member of the professional staff of the University of Tokio, Japan, and now assistant to Sir William Thomson in the physical laboratory of the University of Glasgow. He stated that the apparatus had been made by Mr. James White, the well known scientific instrument maker of that city, and that it is to be used by a former colleague, Professor Milne, of Tokio, in the investigations which are being carried out by him as one of the committee appointed by the British Association for the investigation of the earthquake phenomena of Japan.

An earthquake, he remarked, generally consists of a considerable number of separate to-and-fro movements of a part of the earth's surface. These movements are irregular in period during any one earthquake, and vary very much as to period, duration, and magnitude in different earthquakes. From past experience in Japan, it is inferred that the instrument described in the paper may have to record motions varying from one-tenth of a millimeter to ten millimeters in amplitude, and from one-fifth of a second to something near one second in period; while the duration of the earthquake may vary from half a minute to about four minutes.

In order to determine the amount of movement, it is found convenient to record three rectangular compounds of it—two horizontal and one vertical. The horizontal compounds are recorded by means of the two pendulums indicated at P, Fig. 1. Each of these pendulums consists of a hollow brass cylinder, *c*, filled with lead, and suspended by a silk thread. The cylinder is held deflected from the position in which it would hang with its center of gravity vertically under the point of suspension by means of a thin tube, *t*, which terminates at one end in a sharp, vertical knife edge. One of these tubes is continued by a long and very light index of aluminum foil; while a similar index is attached to the tube on the other pendulum, close to the knife edge, and with its length at right angles to that of the tube. The knife edge rests in a flat V, cut in a hard steel plate, and the point of suspension is regulated by means of screw adjustments, capable of giving motion in three directions at right angles to each other, until it is very nearly vertically above the knife edge, and at such a height that the knife edge bears along all its length. The points of suspension are so adjusted that the planes through the axes of the tubes, *t*, and the suspending threads are at right angles to each other. In this way the indices are parallel to each other, and they are arranged to be in a horizontal plane.

The vertical component of the motion is recorded by means of the mass, M, supported on the end by the lever, *l*, by means of the spring, S, and actuating the vertical index, *i*. To the crossbar, B, which is sharpened to a knife edge on its upper side, there is firmly attached the lever, *l*. The sharpened edge of B rests in a flat V-shaped groove formed on the under side of a steel plate, while the spring is attached to the lever by links working round knife edges. The mass, M, is considerably further from the knife edge than the spring, S, the reason for which is that a moderately long period of free vibration can thus be obtained without an inconveniently long spring. By placing the point of attachment of the spring a little below the line joining the knife edge and the center of inertia of the mass, M, the period of vibration is lengthened to some extent, and it is still more increased by a box, which is mounted on a long horizontal axis and supported at one end of the lever, *l*. In order to give rigidity to the index, *i*, without making it massive, it is made of a very thin tube of aluminum, which is prevented from bending sideways by fine silk threads attached to its point, and to light crossbars of aluminum at its upper end. The threads are kept stretched by means of a light but stiff spiral spring, which presses against the top of the tube. To the point of the index a very flexible piece of aluminum foil is attached, which projects in a horizontal direction, and can be raised or lowered by a thread which passes up the center of the tube and round a pin fixed in the end of the box, B.

These three components of the motion are written on a band of smoked paper, wound around a drum, D, which is kept continuously rotating by a train of clockwork, W. The ends of the indices are arranged to lie in a line parallel to the axis of the drum, so that the corresponding vertical and horizontal components can be easily detected. The pressure of the point of the indices, which write the horizontal components on the paper, can be adjusted by means of threads attached near the ends of the indices, and passed over studs fixed in the pillar which supports the pendulums.

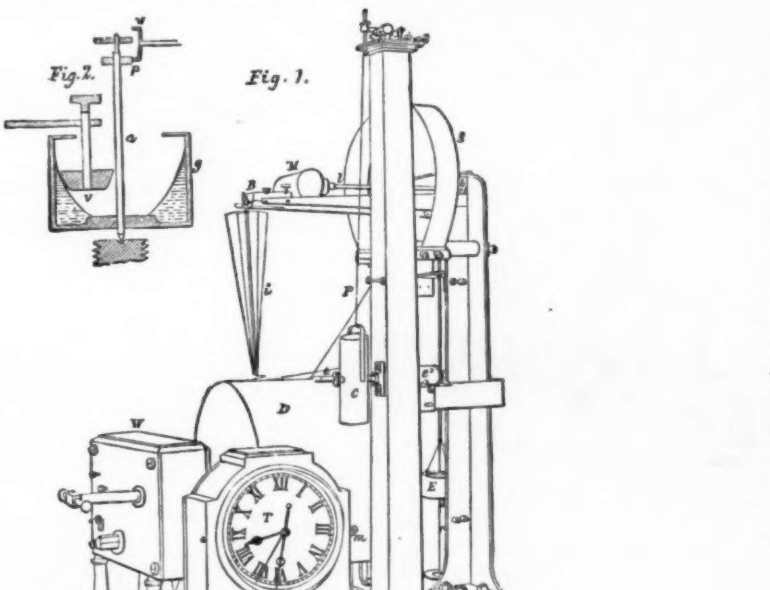
The clockwork, W, is driven by means of two weights acting on separate driving wheels, one on each side of the first pinion, thus, at the same time, giving a pure couple to the pinion, preventing excessive weight on the bearings of the weight barrels, and avoiding the necessity for maintaining power to keep the clockwork in motion during winding. The clockwork is governed by means of a governor in the form shown in section in Fig. 2, where *g* is a light cylindrical box, partly filled with glycerine or some such liquid, and mounted on a vertical axis, *a*, which in this instrument works in jewels at top and bottom. By means of the pinion, *p*, and the crown wheel, *w*, the box, *g*, is geared to the clockwork. The governing action is obtained by causing the liquid to come in contact with a fixed vane, *v*, which can be turned to different distances from the side of the box so as to vary the speed.

The action of the apparatus is a follows: Suppose that the earth moves in a direction at right angles to the plane of one of the deflected pendulums, then, since that pendulum is very free to move round a vertical axis, the inertia of the bob of the pendulum causes it to turn relatively to the remainder of the apparatus, and, consequently, the point of the index attached to it will move across the drum through a distance depending on the length of the pointer, and the distance of the instantaneous axis of the bob from the knife edge. There will not, however, be any motion of the other pendulum. The same is true of motions at right angles to the other pendulum, or to the lever, *l*; and hence if the motion be inclined to all of these, each one will indicate its own component, thus determining the nature, magnitude, and direction of the movement.

The duration of the earthquake is obtained from the known rate of motion of the drum, D, and the length of the record on the smoked paper

The time of occurrence is obtained by means of the time piece, T, and a system of magnets and circuit-closing apparatus. The circuit-closer is shown at E, and consists of a small pendulum, the bob of which is made to turn a light metallic tube, *r*. This tube is carried on a point resting in a conical hole in a rod rigidly attached to the framework, and it is pivoted to the pendulum by a point resting in a conical hole pierced in a small block on the end of a fine spring, so attached to the bob of the pendulum that the conical hole is under its center of inertia. The lower end of this tube hangs in the center of a dimple formed by capillary attraction in the surface of a cup of mercury, over a thin iron pin fixed in the bottom of the cup.

When the framework of the apparatus is slightly shaken, the point of the tube cups into the mercury, and thus closes the circuit of the electro magnets, e_1 e_2. The electro-magnet, e_1, attracts an armature, to the end of which is attached an index, the point of which is in the same line with the ends of the indices for writing the motions on the drum, D, and thus makes a mark on the smoked paper, which shows at what part of the shock the circuit was closed. The magnet, e_2, at the same time relieves a catch, and allows the weight, *m*, to fall, turning a shaft which passes through behind the dial of the clock. This shaft is provided with two small projecting wheels, which push the dial suddenly forward on the hands. The hands are provided with ink pads, and thus leave a mark on the dial indicating the time at which the circuit was closed. Immediately after the circuit is closed through the mercury, it is again broken by means of a simple circuit-breaker, thus preventing useless waste in the battery.



THE EARTHQUAKE RECORDER.

THE EXTRACTION OF GOLD.

"And is not gold the god of earth?"—P. J. Bailey.

It is in these days justly and generally considered as a humiliating failure if in any industrial operation we do not secure practically the whole of the valuable products. The farmer seeks to reap and garner in the entire crops which have grown and ripened on his acres. If prevented by bad weather he bewails his bad luck, if foolish; and if prudent and energetic, he secures a Gillwell harvest-drying machine. The manufacturer, of every kind and grade, is always on the alert to utilize the whole of the raw materials which enter his factory, and if any waste products are formed he moves heaven and earth to turn them to account, or to extract from them some portion at least which may have a market value.

Instances of the success of such endeavors are familiar not merely to practical men in any department, but to the whole reading public. The prevention of waste and the utilization of refuse, from coal-tar down to the waste soapsuds of the woolen mills, have served "to point a moral and adorn a tale" almost to weariness.

Such being the undoubted tendency of the age, it may strike us as strange—as scarcely, in fact, credible—that in an important metallurgical process fully one-half of the substance sought for is, in these days when science and practice are supposed to walk hand in hand, still allowed to go to waste. It will not lessen the surprise of our readers on learning that the material thus wasted is—gold!

So unexpected is this statement that we think it necessary to present briefly the testimony of mining engineers, assayers, and others of long and special experience. Thus Prof. Jack, geologist to the government of the Colony of Queensland, says: "I believe that from 50 to 90 per cent. of the gold contained in some of our complex ores is being lost."

From California, and from the gold-mining districts of America generally, comes substantially the same complaint. Of this we may be convinced on reading over the last report issued by the directors of the United States Mint, at Washington. In this report we find the testimony of Mr. B. Paul, one of the oldest and best mining authorities of California. He says: "As far as California is concerned, I am satisfied that not more than 40 per cent. of her gold is extracted (*i. e.*, 40 per cent. of all contained in the stone that has been treated). . . . Our present general system of mining is based upon the idea that gold is mainly coarse, while examination will show that the high percentage is in atoms finer than flour itself. In my experiments gold has been taken up so fine that it would not subside in distilled water in less than from five to ten minutes." He asks further, "Can you save gold of this kind by running water down stream? Can you obtain gold of this kind without minute reduction? Therein lies the secret of high assays before working and small returns after."

Prof. Eggleston, one of the most eminent metallurgical chemists of America, calculates the loss at "between 50 and 60 per cent." of the total gold present in the ore operated upon.

Mr. C. S. Dicken, F.R.G.S., in a paper read in March last before the Royal Colonial Institute, quoted the amount of gold actually contained in the "Disraeli pyrites" from the Charters Towers District, Queensland, as being on an average 4 ozs. 14 dwts. 13 grains per ton. But the quantity of gold actually obtained from this ore on the present system is only 1⅛ ozs., or a loss of 70 per cent. Another Queensland sample, Mr. Joske's "Ravenswood pyrites," gives on assaying 2 ozs. 18 dwts. 19 grs. of gold to the ton. But on the ordinary system of working it cannot be treated at all at a profit, and is hence lying idle.

In short, summing up all the facts and all the other evidence bearing upon the question, we can only reaffirm the statement made in a former volume of the *Journal of Science*, that "when treating the most tractable of the sulphurets, battery amalgamation (*i. e.*, the process at present in use in California and Australia) does not secure more than 45 per cent. of the gold."

We may here glance at the change which has latterly come over gold mining and gold finding in general. When the auriferous fields of California and Australia were first opened up, the precious metal was obtained in nuggets of differ-

ent sizes, and in grains or sand, which, though, small, were distinctly visible to the naked eye.

These grains and nuggets were obtained by washing, and subsidence from the sands, gravels, and other *detritus* resulting from the weathering of auriferous rock. The process was simple, and required little of either capital or metallurgical skill. But these washings or diggings have been practically exhausted. Whether similar deposits may or may not exist in Central Africa, in New Guinea, or in unexplored parts of South America, is not here the question.

The gold-miner has now to go to work in a more systematic manner. Quartz reefs—*i. e.*, beds of quartz rock containing auriferous pyrites—occur sometimes near the surface, but sometimes only at considerable depths, and, contrary to a popular notion, these reefs do not necessarily become poorer the deeper the miner descends, but very frequently richer. Hence the ordinary practice is now to sink down to or below the reef, to drive levels, break up the stone, and send it up to the surface for further treatment.

This gold-stone, however, differs not merely in the percentage of gold contained, but in other features which have a very important bearing upon the process of extraction. Where merely quartz rock and iron or copper pyrites accompany the gold and silver, the process is comparatively simple; but when, as is often the case, the sulphurets of antimony, lead, zinc, etc., occur, there is great difficulty, waste of the mercury used, and a loss, as we have seen, of the greater part of the gold demonstrably present in the stone.

The method of extracting the gold from the stone may be found described in full detail in every text-book of metallurgy; still, for the better understanding of what has to follow, it is here described in outline. The lumps of quartz rock are ground up, by means of stampers with water, to such a degree of fineness that it can pass through a sieve containing 225 apertures to the square inch. It is then ground up with mercury, and washed over a series of amalgamated copper plates and flannel filters, by which the gold is supposed to be arrested. In reality very much of it, as we have seen, escapes. The powder of the rock is far too coarse; many minute particles of gold—locked up, so to speak, in the center of these particles—escape the action of the mercury altogether. Much of the gold, too, amalgamated or not, floats away on the surface of the water and is lost. Hence Locke, probably the first authority on the subject, though he did not see his way to doing away with the use of water in the extraction of gold from quartz stone, calls it "the greatest robber."

Further, by grinding up with the wet mass no small portion of the mercury is rendered "sick," as the technical term is. In this state it is incapable of readily combining with metallic gold or silver, and floats away on the surface of the water in a fine film. This sickening or killing of the mercury is very much promoted if a little oil or grease from the machinery finds its way into the amalgamation-pan. If any one wishes to see what sick mercury is, he need only grind a little of this metal up in a mortar with water and fine sand or earth. If he continues this process long enough, he will find that the metal loses its tendency to run together in globular drops, and can only be collected together with great difficulty.

The water also facilitates the action of sulphurets of antimony, etc., upon the quicksilver. Sometimes, indeed, where these ingredients are abundant, the whole, as the miners term it, gets into "a mess," from which neither the gold can be extracted nor the mercury recovered on paying terms.

In consequence of the deficient yield of many of the kinds of quartz rock, and the practical impossibility of working others at all, some of the mines in Queensland have been abandoned, and others are carried on at a profit far below what they ought to yield. At the same time the "tailings," or residues of ore which have been ground and submitted to the amalgamation process, have accumulated to the extent of many thousands of tons. These tailings still contain a very fair proportion of gold, as is proved by the assay, but they cannot on the ordinary principle be worked at a profit.

In consequence of this annoying state of affairs Mr. W. Pritchard Morgan, a North Queensland mine owner, and Mr. J. Needham Longden, an Australian mining-engineer and metallurgical expert, came over to London about a year ago to consult with the leading British and Continental metallurgists, and to devise, if possible, some more excellent way. After many and we may say costly experiments, they came upon a totally new process, which in the opinion of the best judges, and, what is more, in actual trials on the large scale, bids very fair to get over the difficulties which we have above enumerated.

The inventors propose, in the first place, to comminute the ore not in a wet state, but perfectly dry. The pulverizing process is effected not by means of a battery of stampers, but by means of a "Jordan" pulverizer. This apparatus acts not by grinding or stamping, but by impact or concussion, something after the manner of a Carr's disintegrator.

The stone is reduced to a powder as fine as flour, so that it passes through a sieve of 8,100 meshes to the square inch, or, in round numbers, forty times as fine as is done in the old process. Hence all the loss dependent on the circumstance that much gold remains still locked up within the grains or fragments of quartz or pyrites is got rid of. The use of water is dispensed with entirely, and though the pulverizing is so much more perfect it is effected at an average cost of £8 per ton, as against £9 10s. per ton by the stamping process, so that here already there is a saving of 30s. per ton.

We come next to the amalgamation. The mercury is applied dry and hot. The ore, reduced as above to an impalpable powder, is passed upward through a column of heated mercury 30 inches in height, and during this passage it is kept constantly distributed through the mercury by an ingenious self-acting apparatus. The details of this part of the process can not be intelligibly described without the use of plates, or, better still, of a working model. We can merely say that the ground ore is fed into a hopper at the top of a revolving tube.

Passing down this it is centrifugally forced into the mercury, and would then, in consequence of its lower specific gravity, at once rise to the surface. To prevent this too rapid escape it is constantly agitated in the mercury by a set of revolving blades. These can be adjusted in their number, in their speed of rotation, and in the angle at which they are set, so that the pulverized ore can be kept in contact with the heated mercury for a longer or a shorter time, according to the quality of the stone which is being operated on.

A steam jacket outside the tube maintains the mercury at the temperature desired. When, finally, the ground ore reaches the top of the column of mercury, it meets a strong blast of air which blows it across the concentrating chamber. "The particles of sand fall in different parts thereof in accordance with their specific gravity, the light waste being conveyed by the air-current to a waste-pipe which conducts it away."

It will, of course, be evident that as any particle of gold combines with the mercury to form an amalgam its specific gravity is increased, and it falls down to a conical receptacle in the bottom, where it can be let off from time to time as convenient.

It is scarcely necessary to insist on the vast advantages of this method of amalgamation over the old wet process. The mercury, hot and dry, comes into immediate and close contact with every particle of gold or silver present, which can hence scarcely escape without amalgamation. The water is no longer there to interfere or to carry away fine films of gold upon its surface, the mercury does not become sick, and the whole process is completely under control.

We must, however, beg leave to make one suggestion; so far, as we perceive, the inventors purpose using pure mercury. We submit that, especially in cases where antimony sulphides, etc., are present, they would find it advantageous to use the sodium-amalgam, first proposed by Mr. W. Crookes, F.R.S., and which has done good service in the hands of metallurgists in various parts of the world. The quantity of sodium which has to be added is so minute that it would neither appreciably increase the working cost nor modify the specific gravity, the fluidity, etc., of the mercury. Consequently the mechanical arrangements for distributing the ground ore through the mercurial column would remain the same.

Passing, however, from considerations of what should or must be to the records of actual experience, we find the teachings of theory fully borne out in practice. In conjunction with Messrs. Jordan, Son, and Commans, the mining engineers, of 52 Gracechurch Street, the gentlemen previously named have had an extensive plant for the extraction of gold erected at Stratford Market, and have there put their process to the test of work.

It has been found that the "Disraeli pyrites," mentioned above as yielding in Queensland, by the old process, 1½ oz. of gold, or 30 per cent. of the contents as per assay, gives by the new process 4 oz. 5 dwt. 11 grains, or 91 per cent.—a clear gain of nearly 3 ounces. Mr. Joske's "Ravenswood" pyrites, mentioned above as found to be incapable of treatment in Queensland, yielded 2 ozs. 12 dwt. 20 grains, or 89 per cent. of its total contents. This increased yield of the precious metal is obtained, further, not at an increased but at a diminished working cost.

In addition to obtaining a greatly improved production at a reduced outlay, there are certain collateral advantages which must not be overlooked. In the first place, water is dispensed with. This, in a country like Britain, may seem a trifling point; but in many gold fields—in Australia, California, and South Africa—water is often very scarce, and the introduction of a process in which it is not required will be no small boon to the mining communities.

Another consideration is that the process is self-acting. The amalgamation apparatus may be locked up in a strong room, and will go on with its duty undisturbed. Thus there is neither opportunity for pilfering, nor are the men exposed to the fumes of mercury.

Though this invention emanates from persons more directly connected with the gold industry of Queensland, we must not for a moment suppose that the process is applicable there only. In other parts of Australia, in California, Mexico, etc., the very same conditions prevail, and the same waste is going on for which we have here the remedy. It must especially be noted that though many samples of quartz from the Wynaad and other districts of India are found when assayed to contain fair and even large percentages of gold, yet the mines in question are not remunerative. We are surely warranted in believing that this new process is the condition needed to make these mines commercially successful.

It is estimated that at present the annual output of gold for the whole world is £20,000,000. Now if we leave out of view the inferior stone, the waste ores, and the accumulated heaps of tailings, we may form some idea of the value of a process which, if generally put in practice, must increase this yield by at the least 25 to 30 per cent.

The process has been patented in all countries where gold-mining is likely to be carried on. The patents for the United Kingdom (No. 5,235, November 5, A. D. 1883, and No. 5,236, of the same date) are taken out in the respective names of Thomas Rowland Jordan and of Thomas Rowland Jordan and John Needham Longden. To these specifications we must refer our readers for further particulars.

In pronouncing this new process one that will make an epoch in the metallurgy of the precious metals as signal, doubtless, as that due to Sir H. Bessemer and to Messrs. Gilchrist and Thomas in the treatment of iron, we must not omit to point out that we have taken every precaution to assure ourselves of the *bona fide* character of the invention. With fair play it will especially add greatly to the prosperity of Australia and of India. It deserves, therefore, a full and a candid examination.—*Jour. of Science.*

A STUDY OF THE HORSE'S TROT.

In order to explain the mechanism of the trotting of a horse, we shall take the animal under full headway. The horse shown at A, in Fig. 1, is taking a bearing for the start with his two diagonally opposite feet, *a* and *b*. These feet will leave the ground and approach each other while lifted, and at this moment the body will enter its period of projection and move horizontally forward through the air, responding to the stress of the last purchase, as we see in horse B, Fig. 2. The animal shown at C, in Fig. 2, is finishing his suspension and again taking to the ground. The two feet, a^1 and b^1, are reaching the latter obliquely together. The body, in thus falling, is held and carried forward by the support of these two limbs, and is again projected onward by their leverage.

The trot has two periods, which, in their succession, undergo influences, due to speed or slowness, that act both upon the length of the step and its velocity, without preventing a regularity in the footfall occurring, whether it be the short trot whose imprints do not cover one another, or the long trot, whose posterior tracks exceed the others.

The short trot partakes of a walking gait, and is generally employed in driving public hacks. The extent of ground embraced between each step scarcely differs in length from that found in the ordinary semi-pace of the same animal. It is with good reason, then, that it is also called a contracted trot, since it gains very little ground. It may be kept up for a long time and alternate with those imperfect gaits called ambling and cantering. The regular trot is evidently the most useful and the most agreeable for carriage and horse-back riding. Here the muscular forces of the animal are wisely employed, while at the same time a speed of 240 meters per minute may be kept up. Excellent progress may be made by alternating this trot with the pace, and giving a well limbed horse, whose footprints cover each other, the necessary amount of rest. The difference in the space comprised between the tracks of such an animal will show his fatigue.

It is this ordinary trot, with its regular rise and fall, that

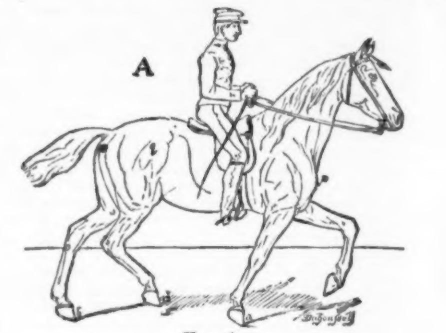


Fig. 1.

we have represented in our sketches. In this trot the space comprised between the bearing feet, *a* and *b* (A, Fig. 1); that is to say, the diagonal length of the step of this gait, equals *p q*, or three-quarters of *o p*, the length of the animal. The feet in the air embrace the same space between their toes, *c* and *d*. The horse, C, in Fig. 3, has just brought his feet, a^1 and b^1, to bear with the same relative distances between these and those that are suspended as in horse A. In B, Fig. 2, which represents the period of suspension, the diagonal feet are likewise equally distant from each other, *e f* being equal to *g h*.

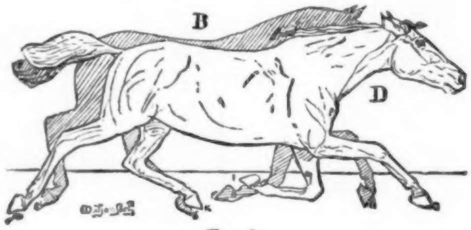


Fig. 2.

In the long trots the tracks made by the hind feet are found to be in advance of those made by the fore feet. In this way a speed equal to that of the gallop is obtained, and much ground is got over. In this kind of trot we believe that the space between the diagonal legs that succeed one another in rising and falling very rarely exceeds the length of the animal's body. The horse shown at D, in Fig. 2, is drawn according to this theory: $i\,k = l\,m$, and each equals the horse's length. The neck, shoulders and head approach the horizontal.

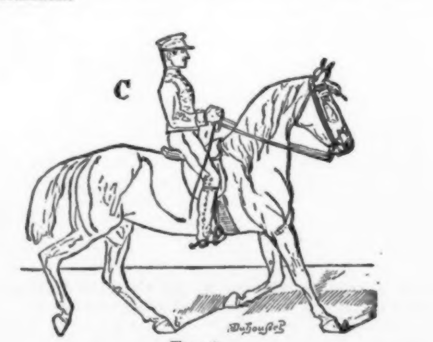


Fig. 3.

This example seems to be capable of characterizing the "flying trot" of the English, or what we call the *trot force*. What authorizes the belief that the extremities only exceptionally embrace lengths that exceed those of the animal's body is that, in a trot executed by a race horse whose attitudes were photographed by Muybridge, we do not find in the distance embraced between the different diagonal positions of the legs lengths that exceed that of the body, however forced be a gait of 727 meters per minute (as it was stat-

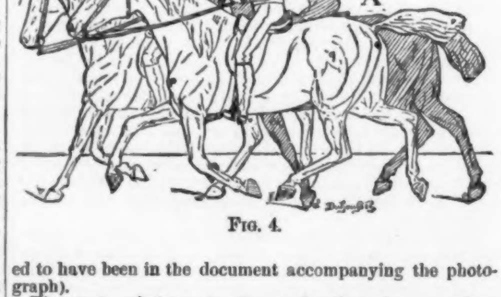


Fig. 4.

ed to have been in the document accompanying the photograph).

The trot, whatever be its acceleration, has reactions that are occasioned by a displacement of the center of gravity, not only from right to left, but especially from back to front, by reason of the leap. It is evident that this

motion will become emphasized on account of the speed, especially if the animal lifts his feet to an exaggerated degree. An endeavor has been made to remedy this fatigue by the attitude called trotting after the English fashion, where the horseman, taking a purchase on his stirrups, rises and remains slightly inclined forward, and does not resume his saddle until the diagonal feet whose thrust he has obeyed again touch the ground. In this way but a single reaction is felt in accomplishing the two periods embraced in the complete trot.

In Fig. 4 we give a general view of the English style of trotting. Here the horseman, *a*, is beginning to obey the action of the horse, A, the toes of whose diagonal feet, *d e*, are pressing the ground with a last thrust. The horse, B, is in complete suspension. The horseman, *b*, has followed the leap, and is free from the saddle and bearing freely upon the stirrups. He will remain in this position when the animal comes down upon the diagonal feet, *f g*, and during the new projection that terminates the complete trot through the striking of the other pair. This is the moment that the horseman, *c*, will feel the reaction upon coming into his saddle; and he will have had but a single jolt for the two shocks of the horse's feet upon the ground, without having felt that of the right diagonal pair.

In this example we have chosen three horses of the same length. The distance of the diagonal feet is therefore equal in each to *p q*, or three-quarters of *p o*, the length of the animal. It will be remarked in Fig. 4 that the horse, B, during the period of suspension, loses height, that is, his withers are nearer the earth than those of the horse, A.

The English trot increases the weight of the forequarters, inasmuch as the horseman in leaning forward puts a load upon the shoulders. All this facilitates the rise of the hind legs and accelerates the elongated trot.

It has taken a long time for the army to recognize the peculiarity of the English style of trotting, which is as useful to the rider as to the horse. It was pointed out thirty years ago by Prof. Flandrin.—*L'Illustration.*

LITTLE DUCK, WINNER OF THE GRAND PRIZE OF PARIS, 1884.

DURING the bright days of the Second Empire (about 1863) Louis Napoleon established the Grand Prix de Paris, amounting to 100,000 francs, in order to make horse racing as popular in France as it was in England. This prize is the most valuable in the world, as it amounted to 142,300 francs this year. It is open to all three-year-olds of all nations.

It is evident that the Frenchmen do not like to see a foreigner carry off the prize, and in case a French horse is the winner, the expression of their joy knows no bounds. The race for the Grand Prix has taken place every year since 1863, with the exception of the year 1871, and has been won by eleven French, eight English, one American, and one Hungarian horse.

The favorite of this year was Mr. Lefevre's Archiduc, from Light Drum by See Saw, but he was beaten two lengths by the Duke of Castrie's Little Duck. Little Duck was ridden by the well known jockey, Tom Cannon.—*Illustrirte Zeitung.*

A FISH-EATING PLANT.

I HAVE recently discovered among the aquatic weeds placed in my aquarium, where I have also a large number of newly hatched perch and roach, a novel and unexpected enemy to the pisciculturist in the bladder traps of *Utricularia vulgaris*, which is capable of catching and killing young fry.

My attention was first drawn to it by observing that several of the tiny fish, without any apparent cause, were lying dead on the weeds, while the rest of the brood looked perfectly healthy and in good condition.

At first I was somewhat puzzled at the strange position in which they were lying, and in trying to move one with a small twig I was still more surprised to find it was held fast by the head in what I thought, when I pulled the plant from the water, were the seed vessels, and a still closer examination revealed the strange fact that others of the little fish had been trapped by the tail, and in one or two instances the head and tail of the same fish had been swallowed by adjacent bladders, thus forming with its body a connecting bar between the two.

At first I was undecided how to act, for I could bring to memory no instance in which I had seen the existence of a piscivorous plant—*i. e.*, one preying on vertebrates—recorded in any book I had ever read; and unwilling to make such an assertion without the opinion of some one better capable of forming a judgment on the subject than myself, I placed one or two good specimens in a glass jar and went to the museum, where I was fortunate enough to see Professor Moseley, who immediately verified my suspicions

According to Bentham's Handbook of British Flowering Plants, the *Utricularia vulgaris*, or greater bladder wort, is widely distributed over Britain, and although it is local, yet where it is found it grows luxuriantly, seldom appearing in the rivers, but chiefly confining its presence to still ponds and deep ditches, the places where it is most likely to work mischief to the young fry.

A peculiar fact in connection with it is, that it has no roots at any time of its life, and the floating, root-like branches which are covered with numerous capillary and much divided leaves are interspersed with tiny green vesicles, which were supposed by a former school of botanists to be filled with water, by which means the plant was kept at the bottom until the time of flowering, when the water gave place to air, and the plant then rose to the surface to allow its bloom to expand.

As a matter of fact, these vesicles exercised no such function, their real work being to entrap minute crustaceans, worms, larvæ, etc., for its support, and without a good supply of which it is impossible to keep it alive in an aquarium.

Their form is that of a flattened ovoid sac, or, in other words, when seen under a low power microscope they are precisely like a human stomach, and they are attached at their hinder extremities, each by a very short and fine pedicle or footstalk in the axil of the leaves.

Each, too, has an opening at the opposite free extremity, somewhat quadrangular in outline, from either side of which project two branched processes, called by Mr. Darwin antennæ.

In fact, I do not suppose they could have received a more appropriate name, because in appearance the whole bladder intimately resembles an entomostracan crustacean, the short footstalk representing the tail.

On either side of the quadrangular entrance several long bristles project outward, and these bristles, together with the branches of the antennæ, form a sort of hollow cone surrounding the entrance, which there cannot be the slightest doubt act as a guide for the prey toward it.

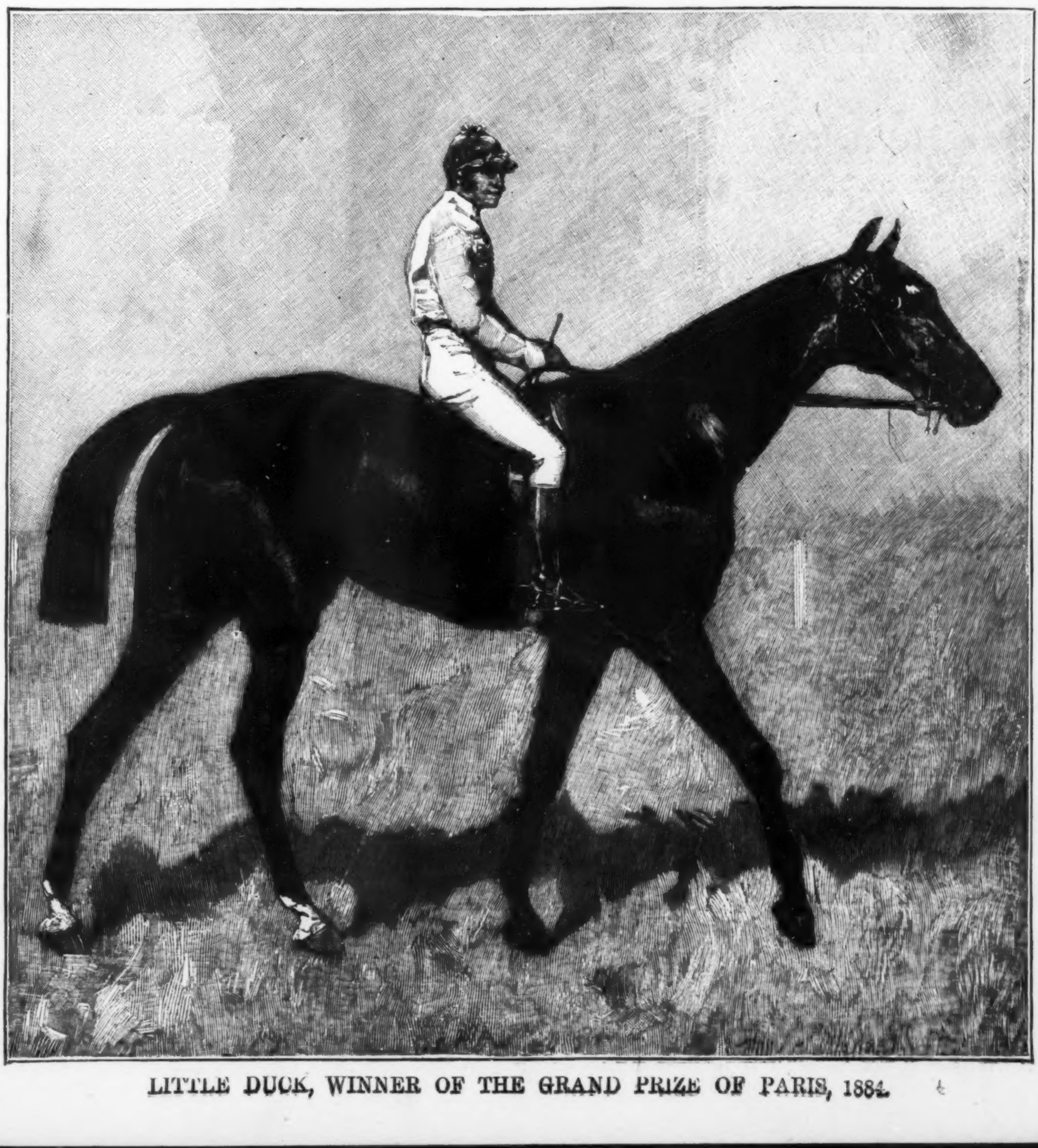
The entrance is closed by a valve, which, being attached above, slopes into the cavity of the bladder, and is attached to it on all sides except at its posterior or lower margin, which is free, and forms one side of the slit-like opening leading into the bladder.

Differing materially from the color of the bladder itself, which is of a brilliant green, the valve is colorless and transparent, and is extremely flexible and elastic.

Animals enter the bladders by bending inward the posterior free edge of the valve, which, from being highly elastic, shuts again immediately.

The edge is extremely thin, and fits closely against the edge of the collar, both projecting into the bladder, and it is extremely difficult, if not impossible, for any animal to escape, although I have observed a long worm do so at the expense of a part of his body; yet, as a rule, it is a case of "all who enter here, lose hope."

To show how closely the edge fits, it was found that a daphnia, which had inserted its antennæ into the slit, was held fast a whole day, and on other occasions long, narrow



LITTLE DUCK, WINNER OF THE GRAND PRIZE OF PARIS, 1884.

larvæ, both dead and alive, were seen wedged between the valve and the collar with their bodies half in and half out the vesicle.

When a fish is caught, the head is usually pushed as far into the bladder as possible till the snout touches the binder wall.

The two black eyes of the fish then show out conspicuously through the wall of the bladder.

So far as is known, there is no digestive process in Utricularia, neither is there any sensibility to irritation. Mr. Darwin was unable to detect either, his opinion being that whatever nutriment the plant obtained from its prey was by absorption of the decaying matter, and it would appear that the longer of the two pairs of projections composing the quadrifid processes by which the vesicles are lined, which project obliquely inward and toward the end of the bladder, acts, together with the spring valves at the mouth of the bladder, in utilizing each fresh struggle of the captive for the purpose of pushing it further inward. If any of my readers wish for specimens of this interesting plant, I shall be enabled in a few days to forward them at a very nominal cost.

"LILIES OF ALL KINDS."

Of its destructive powers all I can say is, that out of 150 newly hatched perch placed in a glass vessel, only one or two were alive two days subsequently, and I hope in a few days to be in a position to speak of its powers *en natura.*—*To G. E. Simms, Jr., in the English Fishing Gazette.*

A LILY BED.

WE must at once tell the reader that this is an ideal bed, planted, tilled, and dressed in the imagination of the artist. The illustration, as any lily grower will at once see, is intended, not from an actual picture of any particular bed, but as an illustration of the kind of effect that may be produced by the grouping together of various forms. From an artist's point of view, if there should be an anachronism in the matter, why so much the worse for the lilies; if the gardener cannot insure that all the species shall be flowering at the same time in the open air, so much the worse for the gardener. At any rate, the artist has here given us representations of the stately Lilium giganteum in the background, with the scarcely less imposing cordifolium. Then come Washingtonianum, to the left, japonicum, auratum, testaceum, philippinense, Wallichianum, polyphyllum, nilgerrense, Catesbæi, parvum, album, longiflorum, Humboldti, Parkmanni, dalmaticum, chalcedonicum, oxypetalum, elegans, davuricum, nepalense, Davidii, and pomponium. We do not think even the Wisley Woods could produce such a show. Happy artist!—*The Gardeners' Chronicle.*

NICKEL ORE FROM NEVADA.

By SPENCER B. NEWBERRY.

WITHIN the past year have appeared frequent references to the occurrence of nickel ores in Churchill Co., Nevada, all seeming to indicate that a very valuable source of supply of nickel has come to light. Through the kindness of Chas. Bell, Esq., of Sacramento, one of the discoverers of the deposit, I was able to obtain a complete series of specimens from the different levels so far opened, namely, the 10 ft., 45 ft., and 60 ft. level, and the 80 ft. drift. The specimens amount in all to about 30 pounds in weight, and are by far the finest masses of nickel ore I have ever seen.

The sample from the greatest depth (80 ft.) consists of nearly pure *niccolite*, which in the 60 ft. and 45 ft. specimens show the progress of oxidation and hydration, this action appearing more complete as the surface is approached. The specimen from the 10 ft. level (nearly eight pounds in weight) consists entirely of the hydrated arseniate, or *annabergite*, with but a small amount of impurity. The analysis of a sample of the entire mass gave:

NiO	33·71 per cent.
As_2O_5	36·44 "
H_2O	24·77 "

The remaining five per cent. represents small quantities of iron, copper, and insoluble residue, with traces of cobalt.

In his letter accompanying the specimens, Mr. Bell gives the following description of the deposit:

"The property is situated in Cottonwood Campus, Churchill Co., Nevada. The ledge is perfectly incased, running 6,000 ft. N.E. and S.W., when it pitches into the Carson Desert and is lost. The ledge is thirty feet between walls, the mineral lying in veins, of which there are thirteen in all, each from ten to thirty-five inches wide. The gangue which separates these veins of ore is in layers from four to eight inches wide, and consists of silica, iron, lime, and magnesia. The same character of minerals extends throughout the whole length of the lead."

In view of the extraordinary purity and richness of the ore, there can be little doubt that, if future developments should bear out the present indications outlined in Mr. Bell's description, the mines of Nevada will eventually become a very prominent source of the world's supply of this valuable metal.—*Am. Jour. of Science.*

HOW TO MAKE A PHOTOGRAPHIC BACKGROUND.

J. R. SWAIN says in *The Photographic Times:*

"Procure unbleached muslin the length and width desired, stretch it tightly on the frame. Then prepare the paint by mixing white lead and lampblack with linseed oil and turpentine till it is about the consistency of thick cream. Use about equal parts of oil and turpentine, add the lead first and then the lampblack, a little at a time, till the proper shade is obtained.

"Now dissolve about a five-cent bar of common yellow soap in three quarts of boiling water, add this to the paint till the proper consistency is obtained so as to spread well. Apply this to the cloth with a good brush. Give it two coats, and, for once, you will be pleased. The background will be limber, can be folded, rolled, or wadded up without injury, will not rub off, but must be kept dry."

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